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DIGITAL CORRELATION TRACKER, PHASE I COMPUTER SIMULATION

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The conclusions derived from an analytical investigation of the performance of several trackers are described in this final technical report on Phase I of the Digital Correlation Tracker Program. The trackers investigated utilize edge, centroid, and digital correlation algorithms to derive error signals for directing the line of sight of an imaging sensor at a target within its field of view. A Computer Simulation Package for implementation on the CDC 6600 was developed for this analysis. Real input target imagery

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ABSTRACT (cont'd)

data were supplied from the AFWL Field Test Telescope. A preliminary digital correlation tracker design for mechanization of the correlation algorithm which demonstrated most precise tracking performance is presented together with the plans for a second-phase effort for its fabrication and test.

The computer simulation demonstrated the superior performance of the correlation tracker for precise tracking of fine target detail under varying background conditions. The correlation tracker afforded constant gain independent of the pattern of the image and showed the least tracking noise or jitter.

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SECTION I

INTRODUCTION

This report is the final Phase I progress report describing the status of the research and development effort to obtain a digital correlation tracker for precise tracking of airborne targets. Utilization of the full spatial frequency information in the image through the correlation process has been shown to provide the input data required to accomplish more accurate real time tracking than can be attained with edge and centroid tracking processes. The program is comprised of a three-phase effort of analysis, development and test. In the first phase, a computer analysis was conducted to evaluate an optimum digital correlation tracker concept and to compare its performance with that of edge and centroid trackers using processed video tapes of real target imagery. A preliminary digital correlation design configuration was also derived. In the second phase, the hardware design will be finalized and an electronics package suitable for installation in standard rack-mounted 19-inch drawers will be tested in the laboratory again using video tapes of real target imagery. In the third and final phase of the program, the digital correlation tracker will be installed in the existing pointing and tracking system at AFWL and its performance demonstrated.

The following sections of this report present a review of the effort conducted during the first phase of the tracker development program and the results achieved. In Section 2 the various tracking algorithms which were implemented in the computer simulation are described. These included a centroid tracker algorithm, an edge tracker algorithm, and various candidate digital correlation tracker algorithms. The correlation algorithms discussed incorporated approximations to the true correlation calculations to reduce computation time and permit real time processing.

In Section 3 the Computer Simulation Package (CSP) is described. This package is the set of computer programs developed to simulate the tracking problem and predict the performance of trackers employing the various algorithms. The first portion of the CSP is the referencing program which accepts digital input imagery data and locates the precise position of an operator-selected target in each frame of input imagery. This referencing program uses the exact correlation computation to find the target and eliminate any inaccuracy in its location due to motion of the image sensor line of sight. The remaining portion of the CSP described in paragraph 3.2 is the tracking program which accepts referenced input imagery from the reference program, offsets the target position in a random manner, and measures the ability of 3 tracker algorithms (edge, centroid and correlation) to derive accurate tracking error signals.

Section 4 describes the processing required to digitize input imagery data and develop a data tape suitable for input to the CSP on a CDC6600 computer. Procedures used for processing both TV and IR imagery are presented. The TV data processed for the final production runs of the CSP and for comparison of the performance of the selected correlation tracking algorithm with that of centroid and edge trackers are shown in Appendix IV. Section 5 then presents an analysis of the data obtained through the use of the CSP including both the early runs and the final production runs. The raw data from the computer production runs are reproduced in Appendix V. Runs number 80, 82, 84, and 86 were made with the TV data inputs shown in Appendix IV as data runs number 2, 3, 4, and 5, respectively, except that run number 84 used a digital data tape made from an earlier processing of the same data frames shown in data tape number 4 without a time code reference display.

In Section 6 of the report the results of the preliminary digital correlation tracker design effort are presented with block diagrams of the circuits and a listing of the principal components which will be used. The report is then completed with a summary of the conclusions derived from this Phase I effort and the recommendations for future program activities in Sections 7 and 8.

SECTION II
TRACKING ALGORITHMS

This section details the tracking and pre-processing algorithms that are simulated in the Computer Simulation Package (CSP). Edge, centroid, and correlation tracking are discussed as well as various threshold and differentiation (gradient) pre-processors. The correlation track algorithms have been generalized to accommodate potential growth in the form of higher frame rate and/or larger picture size systems.

Three types of tracking systems were investigated in this study:

- Edge Tracking
- Centroid Tracking
- Correlation Tracking

In addition to the tracker types, the following pre-processing methods were also investigated:

- Threshold video to form binary patterns
- Patterns which are linear above a threshold
- Linear (nonthreshold) patterns

The edge tracker, after initial preprocessing, operates on binary patterns only and the centroid tracker is restricted to threshold (binary or linear above a value) patterns; the correlation tracker can operate with any of the preprocessing forms.

Video presentations to all tracking configurations are given in 32 by 32 matrices. The gray level or intensity value of each element of the input matrix is quantized in a number of binary levels (up to 64) as specified by data. Video operated on by the trackers (except for correlation) is contained within a track window which is a submatrix of the input picture matrix. Both the window center (X-center and Y-center) and window dimensions (X-dimension and Y-dimension) are specified by data; the window center is specified in a larger 64 by 64 matrix representing imagery data from a referencing program which has precisely determined the target's true position. The various matrices are shown pictorially in figure 1.

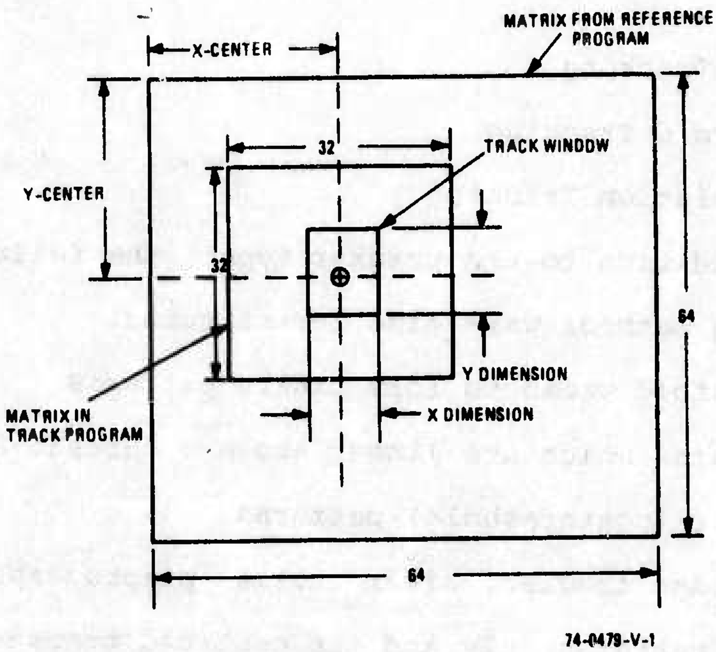


Figure 1. Reference and Track Windows

The track window is always centrally located in the tracker 32 by 32 data matrix. In the following, the 32 by 32 tracker data matrix is labeled P and the 16 by 16 (maximum) track window matrix is labeled W.

Let T be a 32 by 32 preprocessed data matrix. The relationship between the track window W and the preprocessed matrix T is as follows:

$$W(I,J) = T(I+8,J+8) \qquad I,J = 1,\ldots,16 \tag{1}$$

$$\begin{aligned} \text{Let}\quad IX &= X \text{ dimension} \le 16 \\ IY &= Y \text{ dimension} \le 16 \\ J1 &= (16-IX)/2+1 \\ J2 &= J1+IX-1 \\ I1 &= (16-IY)/2+1 \\ I2 &= I1+IY-1 \end{aligned} \tag{2}$$

To accommodate windows smaller than 16 by 16, a modified window matrix WBAR is defined by

$$WBAR(I,J) = \begin{cases} W(I,J) & I1 \le I \le I2,\ J1 \le J \le J2 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

The preprocessed matrices are defined as follows:

a. Binary Patterns

Let d be a positive threshold value

$$B(I,J) = \begin{cases} 1 & P(I,J) \ge d \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

b. Linear above threshold Pattern

Let d be a positive threshold value

$$LB(I,J) = \begin{cases} P(I,J) & P(I,J) \geq d \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

c. Edge Preprocessing

The edge tracker preprocessor is more complex and is described in the following: Only two lines of the pattern need be stored as the pattern is scanned out to determine the "gradient" values. The process is performed as follows: for a continuous pattern defined by some function p(x, y), the magnitude of the gradient $|G(x, y)|$ at some point (x, y) is defined by

$$|G(x, y)| = \sqrt{\left(\frac{\partial p(x, y)}{\partial x}\right)^2 + \left(\frac{\partial p(x, y)}{\partial y}\right)^2}$$

This function is approximated in the discrete case by the following.

The input pattern is specified by a matrix P where P_{ij} is the gray level value in a particular cell, i,j = 1, ---, 31. The rows in the matrix designated by the i value correspond to scan lines and the columns designated by the j value correspond to cells obtained by time gating over a scan. A sub-matrix of the array is given by

P_{ij}	$P_{i, j+1}$
$P_{i+1, j}$	$P_{i+1, j+1}$

The partial derivative $\frac{\partial p(x, y)}{\partial x}$ is approximated by $\frac{\Delta P_{ij}}{\Delta x}$ where

$$\frac{\Delta P_{ij}}{\Delta x} = \tfrac{1}{2}\left[P_{i,\, j+1} - P_{ij} + P_{i+1,\, j+1} - P_{i+1,\, j}\right] \tag{6}$$

Similarly

$$\frac{\Delta P_{ij}}{\Delta y} = \tfrac{1}{2}\left[P_{i+1,\, j} - P_{ij} + P_{i+1,\, j+1} - P_{i,\, j+1}\right] \tag{7}$$

and

$$|G_{ij}| = \sqrt{\left(\frac{\Delta P_{ij}}{\Delta x}\right)^2 + \left(\frac{\Delta P_{ij}}{\Delta y}\right)^2} \tag{8}$$

The operations given above require four subtractions, two squares, an addition, and a square root (divisions by 2 to obtain an average need not be performed). These operations are greatly simplified by noting the following.

Let

$$S_1 = P_{ij} - P_{i+1,\, j+1} \tag{9}$$

$$S_2 = P_{i,\, j+1} - P_{i+1,\, j} \tag{10}$$

and

$$|\overline{G}_{ij}| = \sqrt{S_1^{\,2} + S_2^{\,2}} \tag{11}$$

Simple substitutions show that

$$S_1 = \frac{\Delta P_{ij}}{\Delta x} + \frac{\Delta P_{ij}}{\Delta y} \tag{12}$$

$$S_2 = \frac{\Delta P_{ij}}{\Delta y} - \frac{\Delta P_{ij}}{\Delta x} \tag{13}$$

so that

$$|\overline{G}_{ij}| = \sqrt{2}\, |G_{ij}| \tag{14}$$

and only two subtractions are required. The root mean square calculation is approximated by

$$\sqrt{S_1^2 + S_2^2} \doteq \max(|S_1|, |S_2|) + \frac{\min(|S_1|, |S_2|)}{2} \tag{15}$$

The maximum error in this approximation occurs when $S_1 = S_2$. The left-hand side gives $\sqrt{2}\, S_1$ and the right-hand side gives 3/2 S_1; the maximum error is $(3/2 - \sqrt{2})\, S_1 = 0.086\, S_1$. The form of equation (15) is used and greatly simplifies the calculations in the preprocessor. Also note that only two lines of gray level value storage are required in performing the calculations. For binary patterns, a threshold level d is established and

$$B_{ij} = \begin{cases} 1 & |\overline{G}_{ij}| \geq d \\ 0 & \text{otherwise} \end{cases} \tag{16}$$

For this form, the matrix B is stored after line-by-line preprocessing and operated on after the termination of the sample window (tracking gate).

Because of the absolute value calculations, the edge tracker data is independent of target contrast polarity. Further, as explained in the CSP User's Manual, an automatic threshold routine and "thinning" of the resultant binary pattern are also included in the simulation.

2.1 EDGE AND CENTROID TRACKER ALGORITHMS

The edge and centroid trackers both use the centroid measure in determining error values. The differences in tracker types occur in the preprocessors: a gradient preprocessor is used to extract the "edge" signals for the edge tracker and a threshold

operation is used to produce extended area patterns for the centroid tracker.

The trackers operate in a "biased" mode. That is, measurements are made relative to initial values obtained in frame zero. For n the frame number and X_n and Y_n the measured values, the indicated values $\bar{X}n$ and $\bar{Y}n$ are given by

$$\bar{X}_n = X_n - X_o \qquad\qquad (17)$$
$$\bar{Y}_n = Y_n - Y_o$$

(Note: These data are further modified to determine actual position shifts and by channel gain as will be explained in the section on the Computer Simulation Package. The basic calculations given below do not reflect these modifications).

The centroid measures operate on the modified matrix WBAR and are as follows:

$$S = \sum_{I=1}^{16} \sum_{J=1}^{16} \text{WBAR } (I,J)$$
$$X = \sum_{I=1}^{16} \sum_{J=1}^{16} \text{J*WBAR } (I,J)/S \qquad\qquad (18)$$
$$Y = \sum_{I=1}^{16} \sum_{J=1}^{16} \text{I*WBAR } (I,J)/S$$

(Note: Unbiased measures on a per frame basis could be obtained by subtracting 8.5 from the X and Y values. Such measures represent the true mathematical centroids of the window patterns).

2.2 CORRELATION TRACKER ALGORITHM

The following paragraphs detail the algorithms for a correlation tracker. Operations are performed in an iterative manner for application to picture matrices with dimensions of any multiple of four. Some examples of the calculations are given to indicate their application.

The algorithms trade off mechanization complexity for processing speed. Major complexities occur in the size of the required memory and the number of machine instructions to perform the calculations. Implementation of the algorithm offers growth to higher frame rate systems (requiring proportionately higher processing speeds) and/or larger picture matrices. The actual implementation (covered in the Preliminary Design section) will employ a single iteration process with a 32 x 32 picture matrix and a 16 x 16 sample reference. Although the number of calculations for a single iteration process is much greater than that for a triple iteration process, a much simpler mechanization can be made for the single iteration process at reasonable clock rates and without the use of a computer.

Reference to R & D Status Reports No. 1, 2, and 3 indicate that the initial correlation algorithms employed limited search techniques starting at the previously computed track points. These techniques, though offering minimum computation times, often led to false track points due to local maxima of the cross-correlation function. This led to the conclusion that the search must be performed exhaustively. The algorithm presented below

permits an exhaustive search to be made but with far fewer calculations than would be required with conventional techniques as are employed in the referencing program to establish the true target position.

2.2.1 Correlation Tracker Algorithm Computations

Before proceeding with the detailed calculations, the following notation set is given:

- Upper case letters refer to matrices; lower case letters refer to vectors.
- An m x m matrix R is written

  R(m).
- A submatrix Q of R which is n x n and located within R such that the (1,1) entry of Q corresponds to the (r,s) entry of R is written

  Q(n,r,s).
- Vectors of dimension n derived from Q are designated, for example,

  x(n,r,s).
- The (i,j) element of R(m) is written

  R(m)(i,j).
- The (i,j) element of Q(n,r,s) is written

  Q(n,r,s)(i,j).
- And the jth element of x(n,r,s) is written

  x(n,r,s)(j).

In general, the first set within parentheses designates a particular matrix or vector; the second set within parentheses designates a particular element within the matrix or vector.

As a first step toward minimizing the number of computations to be performed, "marginal" picture vectors are derived from the input picture matrix. Let R(m) be an m x m picture matrix. An x vector is derived by summing the rows in the matrix and a y vector is derived by summing the columns; that is,

$$x(j) = \sum_{i=1}^{m} R(m)(i,j)$$

$$y(i) = \sum_{j=1}^{m} R(m)(i,j) \tag{19}$$

By performing calculations on the vectors, the number of calculations in determining a correlation value is reduced from m^2 to 2m.

The basic savings is accomplished by first determining gross position data on greatly compressed picture representations and then refining the data by exercising limited searches on lesser compressed representations. The compression operation is performed in binary steps in that a 2n x 2n matrix is converted to an n x n matrix. Let P(2n) be the picture matrix prior to conversion and P(n) be the picture matrix after conversion. The conversion calculations are as follows:

$$P(n)(i,j) = P(2n)(r,s) + P(2n)(r+1,s) + P(2n)(r,s+1) + P(2n)(r+1,s+1) \quad . \tag{20}$$

where

$$\begin{aligned} r &= 2i - 1 \\ s &= 2j - 1 \\ i,j &= 1, \ldots, n \end{aligned} \tag{21}$$

An element of a matrix of lower dimension is formed from the sum of four adjacent elements in the matrix of higher dimension.

For the picture matrix $P(2n)$, a submatrix $Q(n,r,s)$ is formed within the picture matrix and represents a track window with starting coordinates (r,s).

The submatrices are formed as follows:

$$Q(n,r,s)(i,j) = P(2n)(r+i-1, s+j-1) \tag{22}$$

$$\begin{aligned} i,j &= 1, \ldots, n \\ r,s &= 1, \ldots, n+1 \end{aligned} \tag{23}$$

As indicated, in a $2n \times 2n$ picture matrix, $(n+1)^2$ submatrices of dimension $n \times n$ can be formed. Each of the submatrices $Q(n,r,s)$ is employed to determine x and y vector representations according to equation 19; i.e.,

$$\begin{aligned} x(n,r,s)(j) &= \sum_{i=1}^{n} Q(n,r,s)(i,j) \\ y(n,r,s)(i) &= \sum_{j=1}^{n} Q(n,r,s)(i,j) \end{aligned} \tag{24}$$

Each of the above vectors is of dimension n.

An example of the above operations is shown below.

Let P(8) be an 8 x 8 matrix given by

$$P(8) = \begin{vmatrix} 0 & 1 & 0 & 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 & 1 & 0 & 1 \\ 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 \end{vmatrix}$$

By equations 20 and 21, a 4 x 4 matrix P(4) is given by

$$P(4) = \begin{vmatrix} 2 & 2 & 3 & 3 \\ 3 & 3 & 2 & 3 \\ 3 & 2 & 4 & 2 \\ 2 & 2 & 2 & 1 \end{vmatrix}$$

By equations 22 and 23, the nine 2 x 2 submatrices derived from P(4) are given by:

$$Q(2,1,1) = \begin{vmatrix} 2 & 2 \\ 3 & 3 \end{vmatrix} \qquad Q(2,1,2) = \begin{vmatrix} 2 & 3 \\ 3 & 2 \end{vmatrix}$$

$$Q(2,1,3) = \begin{vmatrix} 3 & 3 \\ 2 & 3 \end{vmatrix} \qquad Q(2,2,1) = \begin{vmatrix} 3 & 3 \\ 3 & 2 \end{vmatrix}$$

$$Q(2,2,2) = \begin{vmatrix} 3 & 2 \\ 2 & 4 \end{vmatrix} \qquad Q(2,2,3) = \begin{vmatrix} 2 & 3 \\ 4 & 2 \end{vmatrix}$$

$$Q(2,3,1) = \begin{vmatrix} 3 & 2 \\ 2 & 2 \end{vmatrix} \qquad Q(2,3,2) = \begin{vmatrix} 2 & 4 \\ 2 & 2 \end{vmatrix}$$

$$Q(2,3,3) = \begin{vmatrix} 4 & 2 \\ 2 & 1 \end{vmatrix}$$

And, as an example, from equation 24,

$$x(2,2,2) = \begin{vmatrix} 5 & 6 \end{vmatrix}$$
$$y(2,2,2) = \begin{vmatrix} 5 & 6 \end{vmatrix}$$

Starting with the matrix P(2n) of highest dimension, a reference submatrix R(n) is derived and leads to the generation of two reference vectors, rx(n) and ry(n). These vectors are compressed by factors of two to obtain reference vectors to operate on the matrices of lower dimension. The values are given by:

$$\begin{aligned} rx(n)(i) &= rx(2n)(2i-1) + rx(2n)(2i) \\ ry(n)(i) &= ry(2n)(2i-1) + ry(2n)(2i) \\ i &= 1, ---, n \end{aligned} \tag{25}$$

For example, let the reference matrix occur at starting coordinates (3,3) in P(8). The submatrix R(4) is given by

$$R(4) = \begin{vmatrix} 0 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 \end{vmatrix}$$

By equations (6) and (7),

$rx(4) = | 3 \quad 2 \quad 3 \quad 3 |$ $\qquad ry(4) = | 3 \quad 2 \quad 3 \quad 3 |$

$rx(2) = | 5 \quad 6 |$ $\qquad ry(2) = | 5 \quad 6 |$

The maximum correlation position is obtained from the absolute value distance metric; the values, for clarity, are shown as elements of a matrix D(m,n) where m depends on n and the stage of the process. For the first stage, m = n + 1; at subsequent stages, m = 3. For the given example, n = 2 at the first stage of the process (that is, operations on the submatrix of lowest dimension) and m = 3. In general,

$$D(m,n)(r,s) = \sum_{i=1}^{n} [|x(n,r,s)(i) - rx(n)(i)| + |y(n,r,s)(i) - ry(n)(i)|] \qquad (26)$$

For example,

$$\begin{aligned} D(3,2)(2,2) &= | 5 - 5 | + | 5 - 5 | + | 6 - 6 | + | 6 - 6 | \\ &= 0 \end{aligned}$$

The values for other positions are given below by the corresponding entries in matrix D(3,2):

$$D(3,2) = \begin{vmatrix} 2 & 2 & 2 \\ 4 & 0 & 2 \\ 4 & 4 & 8 \end{vmatrix}$$

The minimum distance occurs at entries $[\alpha(n), \beta(n)]$ ($[\alpha(n), \beta(n)] = [2,2]$ in the example). The corresponding entries in the matrix of the next higher dimension are given by:

$$\begin{aligned} \alpha(2n) &= 2\alpha(n) - 1 \\ \beta(2n) &= 2\beta(n) - 1 \end{aligned} \tag{27}$$

For the example,

$[\alpha(2n), \beta(2n)] = (3,3)$

The next step in the process is to perform a 3 by 3 search about the coordinates $[\alpha(2n), \beta(2n)]$. The starting coordinates are given by the following:

Let $i = \alpha(2n)$ and $j = \beta(2n)$. (28)

Then the search table is given by:

(i-1,j-1)	(i-1,j)	(i-1,j+1)
(i,j-1)	(i,j)	(i,j+1)
(i+1,j-1)	(i+1,j)	(i+1,j+1)

For the given example, the vector pair derived from P(4) at search position (2,2) is given by

$x(4,2,2) = |\,2 \;\; 3 \;\; 3 \;\; 2\,|$, $y(4,2,2) = |\,2 \;\; 3 \;\; 2 \;\; 3\,|$

Using the distance measure of equation 26, the matrix D(3,4) is given by

$$D(3,4) = \begin{array}{c|ccc} \alpha(4) \backslash \beta(4) & 2 & 3 & 4 \\ \hline 2 & 6 & 4 & 4 \\ 3 & 4 & 0 & 4 \\ 4 & 10 & 6 & 6 \end{array}$$

The minimum occurs at $[\alpha(4), \beta(4)] = (3,3)$ and corresponds to the initial reference position as required. As an indication of the computation savings by this method, a comparison is made between the matrix and vector/compression technique. Suppose the largest input picture matrix is 2n x 2n and a K stage compression process is used. For the matrix method the absolute value difference measure for corresponding values in the reference and picture matrices would have to be computed $(n+1)^2(n^2)$ times. For the vector/compression technique, the dimension of the lowest order vector is $n2^{-K+1}$. The first search is exhaustive and requires $(n2^{-K+1} + 1)^2 \times 2^{-K+2}$ n calculations. The vector of next higher order is of dimension $n2^{-K+2}$ and 9 calculations are made for each vector for a total of $9 \cdot 2^{-K+3}$ n calculations. Similarly, for the next stage, $9 \cdot 2^{-K+4}$ n calculations are made.

The total number, therefore, is

$$2^{-K+2}n \{(n2^{-K+1} + 1)^2 + 18 (2^{K-1} - 1)\}$$

A comparison is made in the following table.

n	Picture Size	K Iterations	Number of Calculations	
			Matrix Method	Vector Method
32	64 X 64	4	1,115,136	1,208
16	32 X 32	3	73,984	632
8	16 X 16	2	5,184	344

An implementation is shown in figure 2.

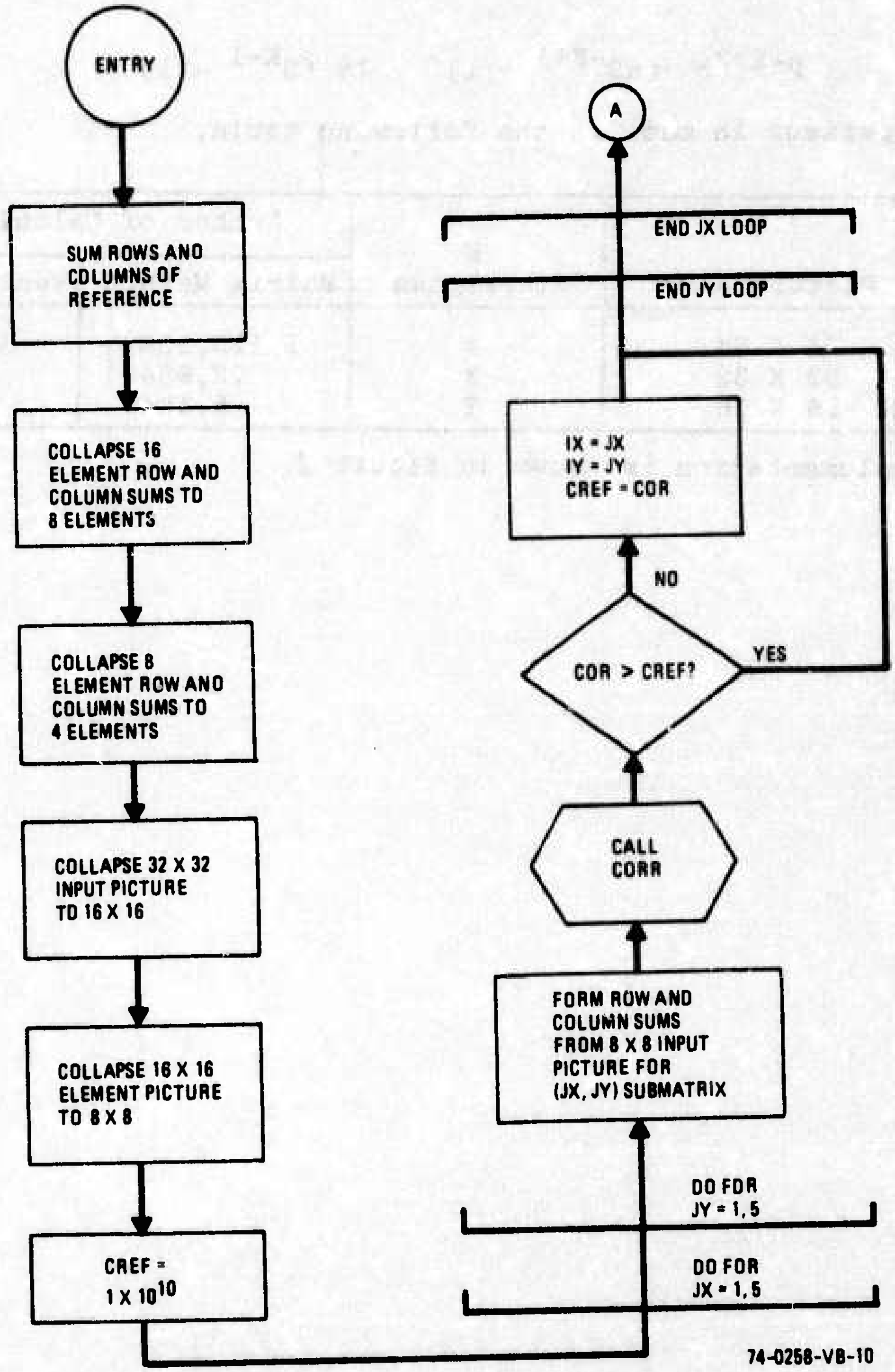


Figure 2. Functional Flow Chart - Subroutine CORREL

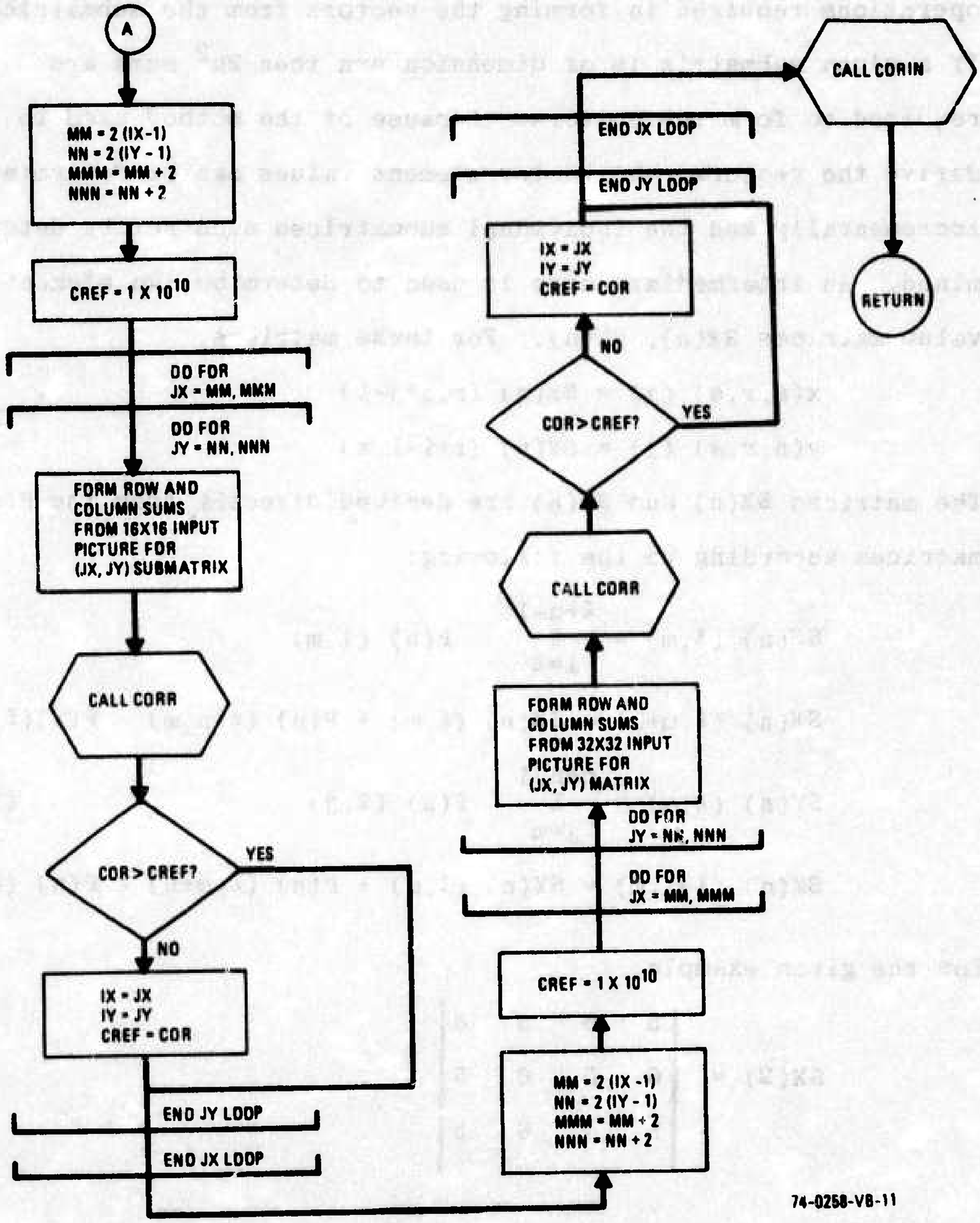


Figure 2. Functional Flow Chart Subroutine CORREL (cont.)

The vector method calculation numbers do not include the operations required in forming the vectors from the submatrices. If a given submatrix is of dimension nxn then $2n^2$ sums are required to form the vectors. Because of the method used to derive the vectors, the vector element values can be determined incrementally and the individual submatrices need not be determined. An intermediate step is used to determine two element value matrices SX(n), SY(n). For these matrices,

$$\begin{aligned} x(n,r,s)\,(j) &= SX(n)\,(r,s+j-1) \\ y(n,r,s)\,(j) &= SY(n)\,(r+i-1,s) \end{aligned} \tag{29}$$

The matrices SX(n) and SY(n) are derived directly from the P(n) matrices according to the following:

$$\begin{aligned} SX(n)\,(\ell,m) &= \sum_{i=\ell}^{\ell+n-1} P(n)\,(i,m) \\ SX(n)\,(\ell,m+1) &= SX(n)\,(\ell,m) + P(n)\,(\ell+n,m) - P(n)(\ell,m) \\ SY(n)\,(\ell,m) &= \sum_{j=m}^{m+n-1} P(n)\,(\ell,j) \\ SY(n)\,(\ell+1,m) &= SY(n)\,(\ell,m) + P(n)\,(\ell,m+n) - P(n)\,(\ell,m) \end{aligned} \tag{30}$$

For the given example,

$$SX(2) = \begin{vmatrix} 5 & 5 & 5 & 6 \\ 6 & 5 & 6 & 5 \\ 5 & 4 & 6 & 3 \end{vmatrix}$$

$$SY(2) = \begin{vmatrix} 4 & 5 & 6 \\ 6 & 5 & 5 \\ 5 & 6 & 6 \\ 4 & 4 & 3 \end{vmatrix}$$

According to equation 29, two vector pairs are computed as follows:

$$x(2,2,2) = (SX(2)\ (2,2),\ SX(2)\ (2,3)\ ) = (5,6)$$

$$y(2,2,2) = (SY(2)\ (2,2),\ SY(2)\ (3,2)\ ) = (5,6)$$

$$x(2,3,3) = (SX(2)\ (3,3),\ SX(2)\ (3,4)\ ) = (6,3)$$

$$y(2,3,3) = (SY(2)\ (3,3),\ SY(2)\ (4,3)\ ) = (6,3)$$

The corresponding submatrices for this example are:

$$Q(2,2,2) = \begin{vmatrix} 3 & 2 \\ 2 & 4 \end{vmatrix} \qquad Q(2,3,3) = \begin{vmatrix} 4 & 2 \\ 2 & 1 \end{vmatrix}$$

As shown in the example, the operations are equivalent but far fewer calculations are required in generating SX(n) and SY(n) as compared to the formation of the vectors from the submatrices. A comparison of the number of add operations is determined below. Assume that the dimensions of the largest P matrix are 2nx2n and that the process is performed in k iterations. Let m = 1,2, -- be the stage of the process. With these definitions, the dimension of the vector, dk, at stage m is

$$dk = n2^{-k+m} \tag{31}$$

The number of operations required to compute either SX(n) or SY(n) is the same; below, the number of operations for SX(n) is determined. In computing SX(n), the first element in each

column involves $n2^{-k+m}$ sums. For m=1, there are $2 \cdot n \cdot 2^{-k+1}$ columns in SX(n); for $m > 1$, there are $n2^{-k+m+2}$ columns in SX(n). Again, for m=1, there are $n2^{-k+1}+1$ rows in SX(n); for $m > 1$, there are 3 rows in SX(n). The second and subsequent elements of each column of SX(n) require two additional sum (difference) calculations. The total number is determined from the following:

T(m) = total number of sums at stage m

NF = number of sums for first element in a column of SX(n)

NR = number of rows in SX(n)

NC = number of columns in SX(n)

$$T = NC\,(NF + 2\,(NR-1)\,) \tag{32}$$

For m = 1

$$T(1) = n2^{-k+2}\,(n2^{-k+1} + n2^{-k+2}) = 3n^2 2^{-2k+3} \tag{33}$$

For m > 1

$$T(m) = (n2^{-k+m}+2)\,(n2^{-k+m} + 4) \tag{34}$$

$$T_k = 3n^2 2^{-2k+3} + \sum_{i=2}^{k} (n2^{-k+i}+2)(n2^{-k+i}+4) \tag{35}$$

The values are tabulated below:

n	k Iterations	T_k Sums
32	4	1800
16	3	576
8	2	216

These numbers are compared with the totals required to extract the individual submatrices.

For m = 1,

$$\bar{T}(1) = (n2^{-k+1} + 1)^2 \quad (n2^{-k+1})^2 \tag{36}$$

For m > 1

$$\bar{T}(m) = 9 \quad (n2^{-k+m})^2 \tag{37}$$

$$\bar{T}_k = n^2 2^{-2k+2} (n2^{-k+1} + 1)^2 + 9n^2 2^{-2k} \sum_{i=2}^{k} 2^{2i} \tag{38}$$

For the individual submatrices:

n	k Iterations	$\bar{T}_k$ Sums
32	4	12496
16	3	3280
8	2	976

2.2.2 Interpolation With The Vector Method

Matrix interpolation to attain tracking accuracy to within less than a resolution element is far too complex to consider in a hardware mechanization. This factor led to an initial mechanization which performed measurements only to the nearest integer value. The simplicity of the vector method does permit a feasible interpolation procedure; the calculations for this procedure are outlined below.

Equation 26 in paragraph 2.2.1 is repeated below.

$$D(m,n)\,(r,s) = \sum_{i=1}^{n} \{ |x(n,r,s)\,(i) - rx(n)\,(i)| + |y(n,r,s)\,(i) - ry(n)\,(i)| \} \tag{39}$$

At the last stage of the process, an optimal coordinate pair (r*,s*) is determined such that

$$D(m,n)\,(r^*,s^*) \leq D(m,n)\,(r,s) \tag{40}$$

for the nine possible choices of (r,s). At this stage of the process the optimal coordinate position values are located to the nearest half element. The interpolation procedure operates on the x and y vectors individually; the x vector calculation is given below.

$$\begin{aligned} \text{Let } x^*(n) &= x(n,r^*,s^*) \\ y^*(n) &= y(n,r^*,s^*) \end{aligned} \tag{41}$$

The interpolation is performed in an n-1 dimensional space with a "shifted" reference vector sx(n-1).

Define

$$sx(n-1)\,(i) = \tfrac{1}{2}\,\{rx(n)\,(i) + rx(n)\,(i+1)\}\,;\ i=1,\ldots,n-1 \tag{42}$$

To a first approximation, sx(n-1) represents a shift of the reference vector rx(n) by one half element. Two vectors u(n-1) and v(n-1) are derived as follows:

$$\begin{aligned} u(n-1)\,(i) &= x^*(n)\,(i);\ i=1,..,n-1 \\ v(n-1)\,(i) &= x^*(n)\,(i+1) \end{aligned} \tag{43}$$

These two vectors are combined with a fractional shift α to form w(n-1, α) as follows:

$$w(n-1,\alpha)\,(i) = \alpha\, u(n-1)\,(i) + (1-\alpha)\, v(n-1)\,(i) \qquad i=1,..,n-1 \tag{44}$$

The interpolation is based on minimizing the square of the Euclidian distance between the vectors sx(n-1) and w(n-1, α). The distance, which depends on α , is given by

$$d^2(\alpha) = \sum_{i=1}^{n-1} \{ sx(n-1)\,(i) - w(n-1,\alpha)\,(i) \}^2 \tag{45}$$

Expanding equation 45,

$$d^2(\alpha) = \sum_{i=1}^{n-1} \{sx(n-1)(i) - v(n-1)(i)\}^2 - 2\alpha \sum_{i=1}^{n-1} \{(sx(n-1)(i) -$$

$$v(n-1)(i)) * (u(n-1)(i) - v(n-1)(i))\} \quad +$$

$$\alpha^2 \sum_{i=1}^{n-1} \{(u(n-1)(i) - v(n-1)(i)\}^2 \tag{46}$$

Differentiating equation 46, setting the derivative to zero, and solving for α gives:

$$\alpha = \frac{\sum_{i=1}^{n-1} \{ (sx(n-1)(i) - v(n-1)(i))*(u(n-1)(i) - v(n-1)(i))\}}{\sum_{i=1}^{n-1} \{ (u(n-1)(i) - v(n-1)(i))\}^2} \tag{47}$$

Since the reference is shifted by a half element, the shift value β is given by

$$\beta = \tfrac{1}{2} - \alpha \tag{48}$$

From equations 42 and 43, equation 47 is rewritten as

$$\alpha = \tfrac{1}{2} \sum_{i=1}^{n-1} \{(rx(n)(i) + rx(n)(i+1) - 2x^*(n)(i+1))*(x^*(n)(i) -$$

$$x^*(n)(i+1)\} / \sum_{i=1}^{n-1} \{x^*(n)(i) - x^*(n)(i+1)\}^2 \tag{49}$$

The same calculation is performed using ry(n) and y*(n). Finally, it is noted that the quantization in the answer is limited only by the number of places carried in the division process.

The hardware mechanization of this interpolation algorithm can be further simplified through use of the absolute value metric. From equation 45, rewritten in terms of the absolute value metric:

$$\overline{d}\ (\alpha) = \sum_{i=1}^{n-1} \left| sx(n-1)(i) - w(n-1,\alpha)(i) \right| \tag{50}$$

$$\overline{d}\ (\alpha) = \tfrac{1}{2} \sum_{i=1}^{n-1} \Big| rx(n)(i) + rx(n)(i+1) - 2x^{*}(n)(i+1)$$
$$- 2\alpha(x^{*}(n)(i) - x^{*}(n)(i+1)) \Big| \tag{51}$$

Step 1

Compute xu vector:

$$xu(n)(i) = rx(n)(i) + rx(n)(i+1) - 2x\ (n)(i+1);$$
$$i = 1, \ldots, n-1 \tag{52}$$

Step 2

Compute xv vector:

$$xv(n)(i) = 2\ (x^{*}(n)(i) - x^{*}(n)(i+1);\ i = 1, \ldots,$$
$$n - 1 \tag{53}$$

Step 3

Cycle through α over the range $0 \leq \alpha \leq 1$:

$$\overline{d}(\alpha^{*}) = \min_{\alpha} \sum_{i=1}^{n-1} \left| xu(n)(i) - \alpha\, xv(n)(i) \right| \tag{54}$$

$$0 \leq \alpha^{*},\ \alpha \leq 1$$

$$\beta = \tfrac{1}{2} - \alpha^{*} \tag{55}$$

As noted, this scheme eliminates vector multiply and divide operations enabling a simpler hardware mechanization. In the mechanization, α is incremented from zero in steps of $\tfrac{1}{2}K$ (K an integer) for a total of $2^{K} + 1$ correlation computations for each axis.

SECTION III

COMPUTER SIMULATION PACKAGE (CSP)

This section details the method and underlying theory in the reference and track programs which comprise the CSP. The reference and track subsections are accompanied by an overview of program organization. Specific detail and usage of the CSP are found in the User's Manual. The performance of the referencing program is the key to the subsequent comparative performances of the different tracking algorithms. This section gives performance data of the referencing program on known synthetic targets and a measure, the effective signal-to-noise ratio, for comparison with live data.

3.1 REFERENCING PROGRAM

To establish a data base for evaluating a number of candidate tracking algorithms, a set of sequential images must first be referenced so that each specific target occurs at a fixed position in a measurement field. This field is described by a 64 by 64 matrix of intensity or gray level values quantized to 64 levels. At the outset, without benefit of "ground truth," the positioning is somewhat subjective especially with regard to objects and backgrounds with complex geometries. The problem is further compounded by random noise which independently modifies each of the input gray level values.

The reference program provides for "relative" positioning of an ensemble of points which comprise a given object on a frame-to-frame basis. Since actual measurement error for the process can not be known without ground truth, a comparison method is employed. This method uses a synthetic target whose position and/or position variations are known. Noise is superimposed on this synthetic target and results in a given effective signal-to-noise ratio. The signal modulation value is derived from the spatial characteristics of the object such that varying geometries and gray level structures lead to varying signal modulation values. The signal-to-noise measure is thus applicable to a wide range of objects which are compared not by shape or gray level structure but rather by the signal modulation value produced by the given shape and gray level structure. Thus, to a first approximation, if two distinct object sets have the same effective signal-to-noise ratio then they will exhibit the same performance in the referencing program. The performance is measured in terms of rms position jitter and track point drift. The basic referencing technique, generation of the test targets and implementation of the specific measures are detailed below.

In examining the referencing technique, the first step is to envision a physical process and then to attempt to find a mathematical model which will emulate the results. In the physical world, one would make photographic positive and negative transparencies of an object on a background and then overlay them in a specific spatial relationship. If the pictures were identical then for some

translation of one picture relative to the other, a neutral gray tone would result on transmission through the overlay. For this case one would say that the images "match" - not only at one point but at all points. At other positions, a melange of gray tones results until the images are almost in perfect registration when a striking result known as a bas relief occurs. (The effect, caused by "edges" around image shapes, is produced in a similar manner by differentiation of video input signals in actual sensor output data. This preprocessing method is used in edge tracker configurations covered in a later section). For any case, an indication of mismatch due to translational effects is given by differences that occur relative to the neutral gray of perfect matching.

Rather than the continuous images of the photographs referred to above, image representations are given by grid overlays on the continuous image where each grid "cell" is assigned an average gray level or intensity value. The spatial quantization produced by the grid is represented by a matrix of intensity values each of which is amplitude quantized into a number of discrete levels. Both the spatial and amplitude quantization are sufficiently fine such that recreation of a photographic image from the matrix data yields an image very close to the original. The referencing program receives input imagery in 100 by 100 matrices, amplitude quantized to 64 levels; output referenced images are 64 by 64 matrices also amplitude quantized to 64 levels.

Input imagery is represented by a sequence of data derived from a sensor which produces pictures at a given frame rate. Referencing is performed on a frame-to-frame basis; that is, a "reference" image (16 by 16 submatrix of the input picture matrix) derived in frame number n is compared with 16 by 16 submatrices derived from the image in frame n+1. Once a "best" match has been found, the particular submatrix yielding the best match in frame n+1 is used as a reference for frame n+2, etc.

A best match position is obtained by first extracting submatrices from the picture matrix and then applying a "distance" metric to the corresponding points (or values) in the reference matrix and picture submatrix.

As indicated in Appendix I, when the norms of the reference and picture submatrices are identical, minimization of the Euclidian distance or maximization of the cross-correlation of the representative forms produce identical results. The distance measure is seen to be equivalent to the positive/negative overlay process; however, in seeking a null for the distance measure, no indication is given of how well the images match. Correlation values range from -1 to +1 and values near +1 indicate an excellent match. Thus, correlation data is used in the reference program and allows for the elimination of "bad" data; that is, a running average of sequential correlation values is computed such that radical departures from this value first cause expansion of the search range and then cause skipping of a data frame if the peak cross-correlation differs by more than 15 percent from the running average value.

(This percentage value is arbitrary and was determined empirically by experimentation. For most runs, the option is never exercised.) It is also noted that although a correlation measure is used in the referencing program the specific measure is too complex and too time consuming to implement in real time. The tracker program which operates on this data employs a much different algorithm which, in fact, is based on a simple distance measure and operates on data of much lower dimensionality than that used in the reference program.

3.1.1 Cross-Correlation Measure

The procedure outlined below locates to the nearest element the position of a 16 x 16 submatrix within an input 100 x 100 picture matrix such that maximum cross-correlation between the submatrix and a 16 x 16 reference matrix occurs. The measure is derived from a standard statistical calculation used to determine the correlation coefficient for two random variables.

Let P be a 100 x 100 input matrix, R be a 16 x 16 reference matrix and $\overline{P}(m,n)$ be a 16 x 16 submatrix of P with starting coordinates (m,n); that is,

$$\overline{P}_{ij}(m,n) = P\,(i + m-1,\ j + n-1);\ i,j = 1, \ldots , 16 \qquad (56)$$

The cross-correlation coefficient at coordinates (m,n), $\rho(m,n)$, is defined as follows:

$$\rho\,(m,n) = \rho\left[\overline{P}(m,n),R\right] = \frac{\mathrm{COV}\left[\overline{P}(m,n),R\right]}{\sigma_{P(m,n)}\ \sigma_{R}} \qquad (57)$$

COV $(\overline{P}(m,n),\ R)$ is the covariance of the submatrix at (m,n), $\overline{P}(m,n)$, and the reference R and is expressed as:

$$COV\left[P(m,n),\ R\right] = E\left[P(m,n),\ R\right] - \mu_{P(m,n)}\mu_R \tag{58}$$

where E is the expectation or averaging operator and $\mu_{P(m,n)}$ and μ_R are the means of the picture submatrix and the reference matrix, respectively. $\sigma_{P(m,n)}$ and σ_R are the standard deviations of the picture submatrix and reference matrix, respectively. The terms of the correlation coefficient expressions (equations 57 and 58) are computed as follows:

$$E\left[\overline{P}(m,n),\ R\right] = \frac{1}{256}\sum_{i=1}^{16}\sum_{j=1}^{16}\overline{P}_{ij}(m,n)\,R_{ij} \tag{59}$$

$$\mu_{P(m,n)} = \frac{1}{256}\sum_{i=1}^{16}\sum_{j=1}^{16}\overline{P}_{ij}(m,n) \tag{60}$$

$$\mu_R = \frac{1}{256}\sum_{i=1}^{16}\sum_{j=1}^{16}R_{ij} \tag{61}$$

$$\sigma^2_{\overline{P}(m,n)} = \frac{1}{256}\sum_{i=1}^{16}\sum_{j=1}^{16}\overline{P}^2_{ij}(m,n) - \mu^2_{\overline{P}(m,n)} \tag{62}$$

$$\sigma^2_R = \frac{1}{256}\sum_{i=1}^{16}\sum_{j=1}^{16}R_{ij}^2 - \mu^2_R \tag{63}$$

These calculations are made over the search range

$$m_1 \le m \le m_2$$
$$n_1 \le n \le n_2 \tag{64}$$

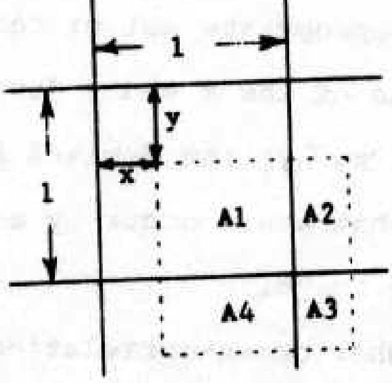
and an optimum coordinate pair (m^*,n^*) is determined such that

$$\rho(m^*,n^*) \ge \rho(m,n) \tag{65}$$

where (m^*,n^*) and (m,n) are bounded according to equation 64.

3.1.2 Interpolation In The Referencing Program

Once the element nearest to the maximum of the cross-correlation function has been found, an interpolation procedure is employed to obtain the location to within fractional resolution elements. The procedure works as follows. Using the coordinates that yield maximum correlation within an element, a slightly larger window is derived from the image. The window contains two more rows and columns than the reference image; e.g., an 18 by 18-element window is derived for the 16 by 16-element reference image. The reference is centrally located in the larger window. The program then extracts 16 by 16 matrices from the 18 by 18-matrix by position shifts determined by area weighting of adjacent cells. This can be explained by reference to figure 3. The initial grid and the gray level values of the initial grid (matrix value P_{ij}, etc.) are shown in figure 3.



$P_{i-1, j-1}$	$P_{i-1, j}$	$P_{i-1, j+1}$
$P_{i, j-1}$	P_{ij}	$P_{i, j+1}$
$P_{i+1, j-1}$	$P_{i+1, j}$	$P_{i+1, j+1}$

Figure 3. Incremental Positioning

The dotted square represents a cell which has been displaced by x and y, $-1 < x, y < 1$. This cell now overlaps four cells in the original array. The overlap produces a new gray level value over the dotted square and this value is determined by area weighting. From figure 3, the area of the dotted square (taken as unity) is segmented into four sub-areas, A1, A2, A3, A4. From the figure, the areas are as follows:

$$A1 = (1 - x)(1 - y)$$

$$A2 = x(1 - y)$$

$$A3 = xy$$

$$A4 = (1 - x)y$$

For $\overline{P}$ the derived matrix, again from figure 3,

$$\overline{P}_{ij} = A1\,P_{ij} + A2\,P_{i,\,j+1} + A3\,P_{i+1,\,j+1} + A4\,P_{i+1,j}$$

(The extra rows and columns in the sample matrix are seen to be required for overlaps beyond the bounds of the initial 16 by 16-element array.) A subroutine determines the derived matrix $\overline{P}$ in terms of x and y and determines the appropriate set of coordinate values in terms of the algebraic signs of the x and y displacements. Hence, given a displacement (Δx, Δy) the derived image $\overline{P}$ approximates the gray level pattern that would occur by an equivalent displacement and sampling of the image.

The program then tests for a higher cross-correlation between the displaced image and the initial one by a binary search procedure which is performed as follows.

Position increments are made according to table I.

Table I. Fractional Search

$x_{k+1} = x_k^* - \frac{1}{2}k$ $y_{k+1} = y_k^* - \frac{1}{2}k$	$x_{k+1} = x_k^*$ $y_{k+1} = y_k^* - \frac{1}{2}k$	$x_{k+1} = x_k^* + \frac{1}{2}k$ $y_{k+1} = y_k^* - \frac{1}{2}k$
$x_{k+1} = x_k^* - \frac{1}{2}k$ $y_{k+1} = y_k^*$	$x_{k+1} = x_k^*$ $y_{k+1} = y_k^*$	$x_{k+1} = x_k^* + \frac{1}{2}k$ $y_{k+1} = y_k^*$
$x_{k+1} = x_k^* - \frac{1}{2}k$ $y_{k+1} = y_k^* + \frac{1}{2}k$	$x_{k+1} = x_k^*$ $y_{k+1} = y_k^* + \frac{1}{2}k$	$x_{k+1} = x_k^* + \frac{1}{2}k$ $y_{k+1} = y_k^* + \frac{1}{2}k$

$k = 1, 2, ---$

$$x_o = 0$$
$$y_o = 0$$

The initial correlation value is $\rho_0\ (x_o, y_o)$. At stage 1 of the process ($k = 1$), nine measurements are made yielding $\rho_1\ (x_1^*, y_1^*)$ where $\rho_1\ (x_1^*, y_1^*) > \rho_0\ (x_o, y_o)$ and

$$x_1^* \epsilon \left\{-\tfrac{1}{2}, 0, \tfrac{1}{2}\right\}$$
$$y_1^* \epsilon \left\{-\tfrac{1}{2}, 0, \tfrac{1}{2}\right\}$$

At stage 2 of the process ($k = 2$),

$$\rho_2\ (x_2^*, y_2^*) > \rho_1\ (x_1^*, y_1^*)$$

where $\quad x_2^* \epsilon \left\{x_1^* - \tfrac{1}{4}, x_1^*, x_1^* + \tfrac{1}{4}\right\}$

$$y_2^* \epsilon \left\{y_1^* - \tfrac{1}{4}, y_1^*, y_1^* + \tfrac{1}{4}\right\}, \text{ etc.}$$

The process continues through 4 stages giving a location of the cross-correlation maximum to the nearest 1/16 of an element.

3.1.3 Corrections For Fractional Positioning

The output pictures can not be fractionally positioned without modifying the input data. Although an approximation to fractional positioning can be obtained using the same procedure noted in the section on interpolation, this procedure results in a loss of image resolution. The loss occurs because the weighted averaging process over the four adjacent cells used to determine a composite value produces spatial filtering dependent on the magnitude of the errors. As a consequence of the above, the sequential images are positioned only to the nearest element in the referencing program, and the incremental error is transferred to the tracker as data.

The incremental and integer coordinate data must be corrected because the reference image for the next frame is not determined at the true maximum correlation position. This point is discussed further below, and an analysis is given for one of the coordinate positions.

Suppose that the true x positions are given by the sequence $\{x_0, x_1, \ldots, x_n\}$. Each element of this sequence is the sum of an integer position n_k and an incremental position ε_k; i.e.,

$$x_k = n_k + \varepsilon_k; \quad k = 0, \ldots, n$$

$$|\varepsilon_k| \leq 1/2 \tag{66}$$

$$\varepsilon_o = 0$$

All measures are relative to the initial position and as such, $\varepsilon_o = 0$. In positioning to the nearest element, an integer shift m_{k+1} is added to x_{k+1} such that

$$|x_{k+1} + m_{k+1} - x_k| < 1/2 \tag{67}$$

Assuming perfect incremental error position data, a value δ_{k+1} is found such that

$$x_{k+1} + m_{k+1} + \delta_{k+1} - x_k = 0 \tag{68}$$

From equation 66,

$$n_{k+1} + \varepsilon_{k+1} + m_{k+1} + \delta_{k+1} - n_k - \varepsilon_k = 0 \tag{69}$$

suppose

$$n_{k+1} + m_{k+1} - n_k = 0 \tag{70}$$

so that,

$$\varepsilon_{k+1} = \varepsilon_k - \delta_{k+1} \tag{71}$$

Now,

$$\varepsilon_1 = \varepsilon_0 - \delta_1 = - \delta_1 \tag{72}$$

$$\varepsilon_2 = \varepsilon_1 - \delta_2 = -\delta_1 - \delta_2 \tag{73}$$

$\cdot$
$\cdot$
$\cdot$
$\cdot$

$$\varepsilon_k = -\sum_{i=1}^{k} \delta_i \tag{74}$$

From equations 69 and 70,

$$\varepsilon_{k+1} = n_k - n_{k+1} - m_{k+1} - \sum_{i=1}^{k+1} \delta_i \tag{75}$$

By equations 66 and 70,

$$|\varepsilon_{k+1}| = |n_k - n_{k+1} - m_{k+1} - \sum_{i=1}^{k+1} \delta_i| = |-\sum_{i=1}^{k+1} \delta_i| \leq 1/2 \tag{76}$$

This condition can be met by modification of m_{k+1} and δ_{k+1}. Suppose that

$$|-\sum_{i=1}^{k+1} \delta_i| = |+\sum_{i=1}^{k} \delta_i + \delta_{k+1}| > 1/2 \tag{77}$$

CASE (1): $$+\sum_{i=1}^{k} \delta_i + \delta_{k+1} > 1/2 \tag{78}$$

Let

$$\begin{aligned} \bar{\delta}_{k+1} &= \delta_{k+1} - 1 \\ \bar{m}_{k+1} &= m_{k+1} + 1 \end{aligned} \tag{79}$$

Then,

$$\sum_{i=1}^{k} \delta_i + \bar{\delta}_{k+1} + \bar{m}_{k+1} = \sum_{i=1}^{k} \delta_i + \delta_{k+1} + m_k \tag{80}$$

and

$$\sum_{i=1}^{k} \delta_i + \bar{\delta}_{k+1} < 1/2 \tag{81}$$

CASE (2): $$\sum_{i=1}^{k} \delta_i + \delta_{k+1} < -1/2 \tag{82}$$

Let
$$\bar{\delta}_{k+1} = 1 + \delta_{k+1} \tag{83}$$
$$\bar{m}_{k+1} = m_{k+1} - 1$$

Then,
$$\sum_{i=1}^{k} \delta_i + \bar{\delta}_{k+1} + \bar{m}_{k+1} = \sum_{i=1}^{k} \delta_i + \delta_{k+1} + m_k \tag{84}$$

and
$$\sum_{i=1}^{k} \delta_i + \bar{\delta}_{k+1} > -1/2 \tag{85}$$

Note that by equations 80 and 84, the modifications to δ_{k+1} and m_{k+1} produce an equivalent position but (with the appropriate choice) the condition of equation 76 is met. Hence, the algorithm positions data according to $\bar{m}_{k+1}$ and indicates output incremental error as $\varepsilon_{k+1} = \sum_{i=1}^{k+1} \bar{\delta}_{k+1}$.

3.1.4 Overview of Referencing Computer Program

The referencing program processes live or synthetic data and generates frame-by-frame outputs for the tracker program. If the data is live, it has been generated from digitized video or infrared imagery and is input from magnetic tape. For synthetic data, the input pictures are generated internal to the referencing program. The output frames for the tracker program are written on magnetic tape.

This program has the basic function of deriving a frame-by-frame reference image of the target. It does this by generating an initial reference from the first picture, based upon user supplied information that specifies the original location of the target. For each subsequent picture, the cross-correlation function, using the current picture and previous reference, is computed. A new reference is derived from each frame,selected such that it is centered about the peak of the correlation function.

The program is capable of processing up to 180 frames of data. Frame-to-frame correlation may be done using as many possible picture positions as the user desires. (Obviously, the 100 x 100 frame cannot be exceeded.) It is possible to change the picture from negative to positive contrast. Synthetic targets may take on any configuration and may be rotated, segmented, jittered, or superimposed upon a noisy background.

An option is provided that allows the user to bypass the tape output, so that a user may checkout new data. In addition, a

large number of print options are available for program verification and data analysis.

CSP is the name of the main or controlling element for the referencing program (figure 4). Initial controls for the program are input through a set of data cards.

The first section of CSP is concerned with the processing of the initial picture. Input pictures are either read from preprocessed tapes or they are generated internal to the CSP itself. The first type of picture shall be referred to as live data and the latter internally generated pictures as synthetic. Regardless of the type of input, the processing performed on the picture in order to derive the reference is the same. The first step, following picture input, is conversion of the picture, if necessary, from negative to positive contrast. Following contrast conversion, the reference is derived from the first picture based upon the card input target coordinates.

In the body of the CSP program, a sequence of operations is performed that derives a new reference from each picture, based upon the peak correlation between the current picture and the previous reference. That is, the reference derived from picture 1 is used to cross-correlate with picture 2 in order to derive reference 2. Reference 2 is used to cross-correlate with picture 3 to derive reference 3, etc. Although the heart of the CSP is the correlation processor, there are a number of necessary peripheral processes required.

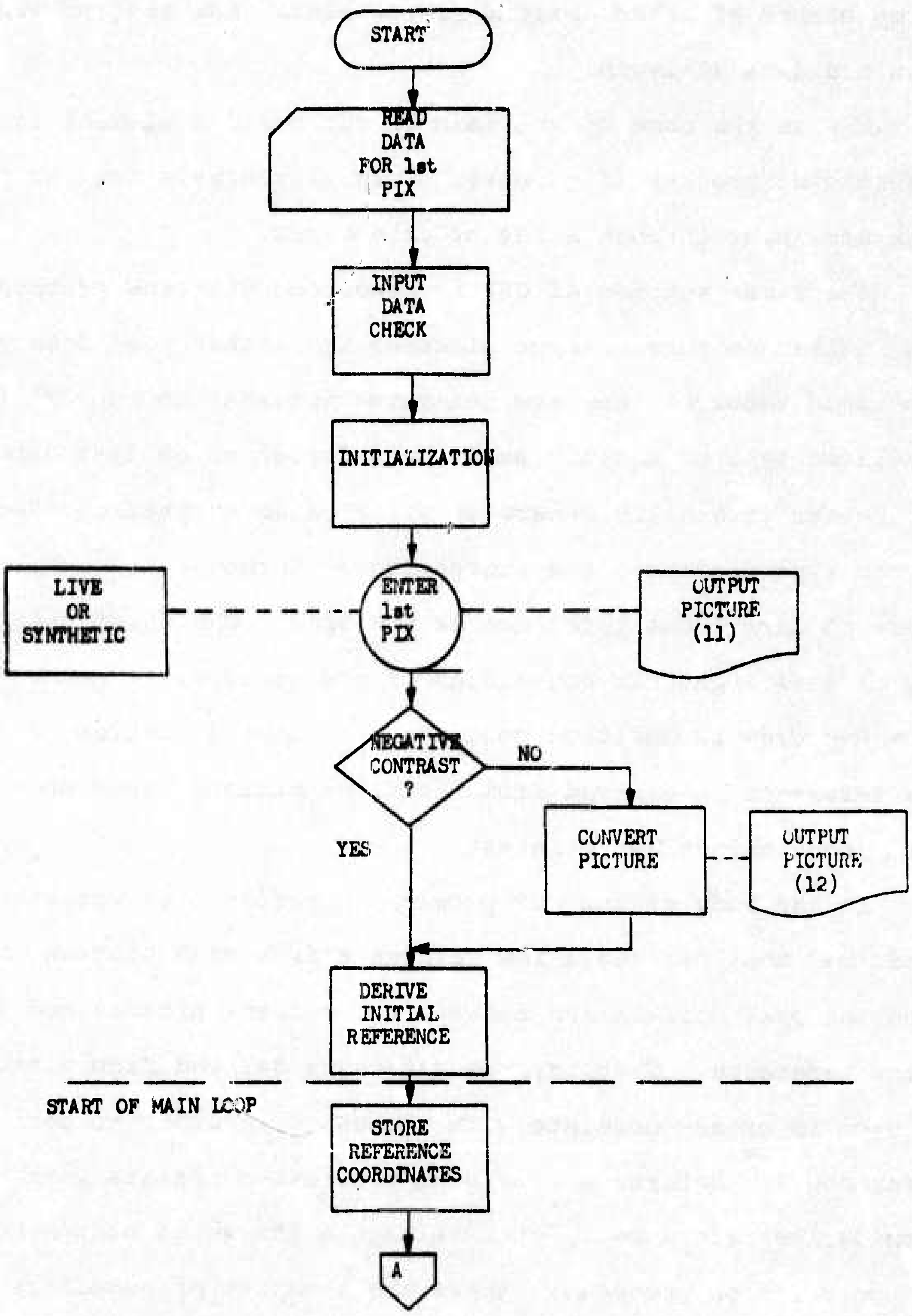


Figure 4. Referencing Program - Functional Flow Chart (1 of 4)

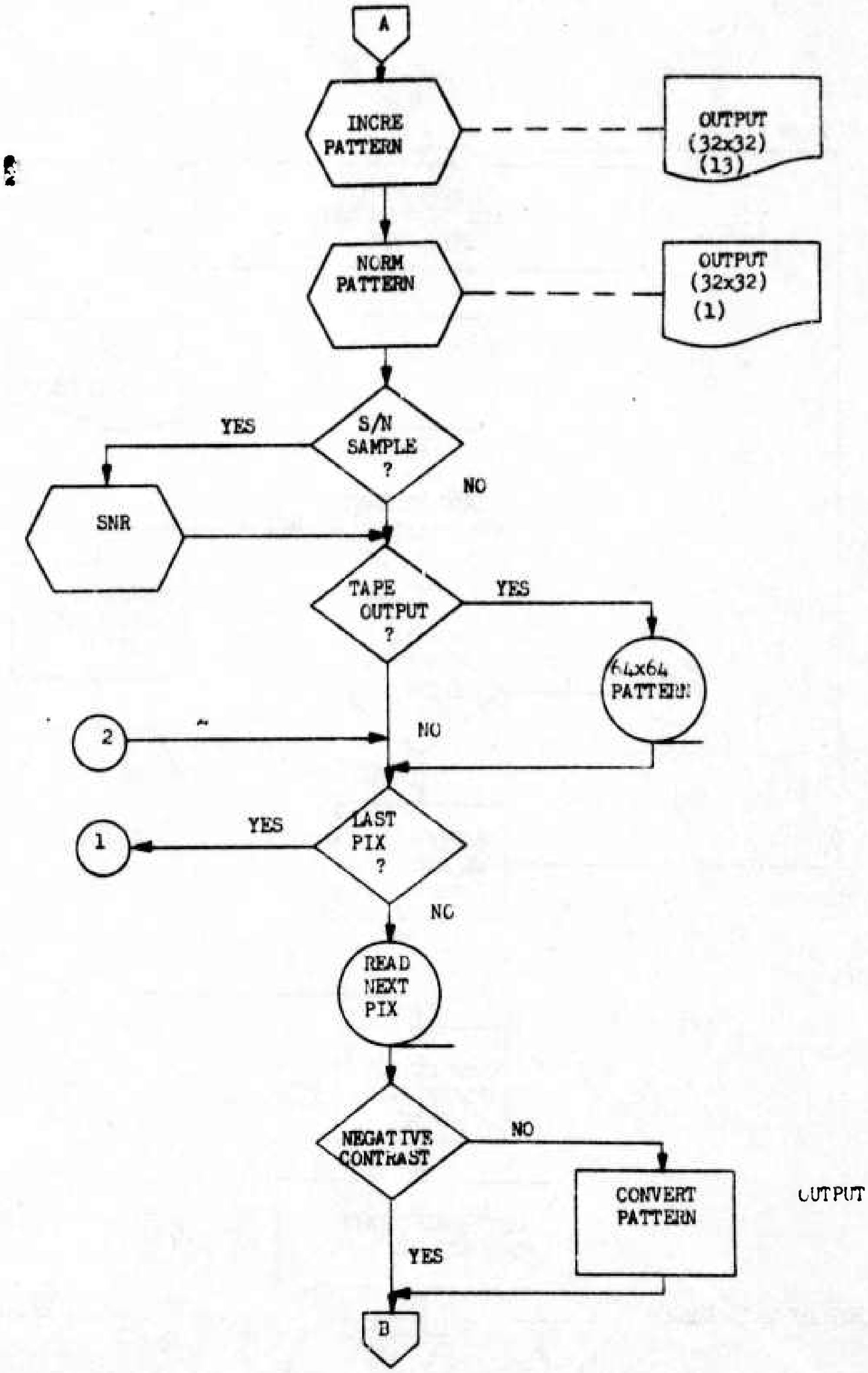


Figure 4. Referencing Program - Functional Flow Chart (2 of 4)

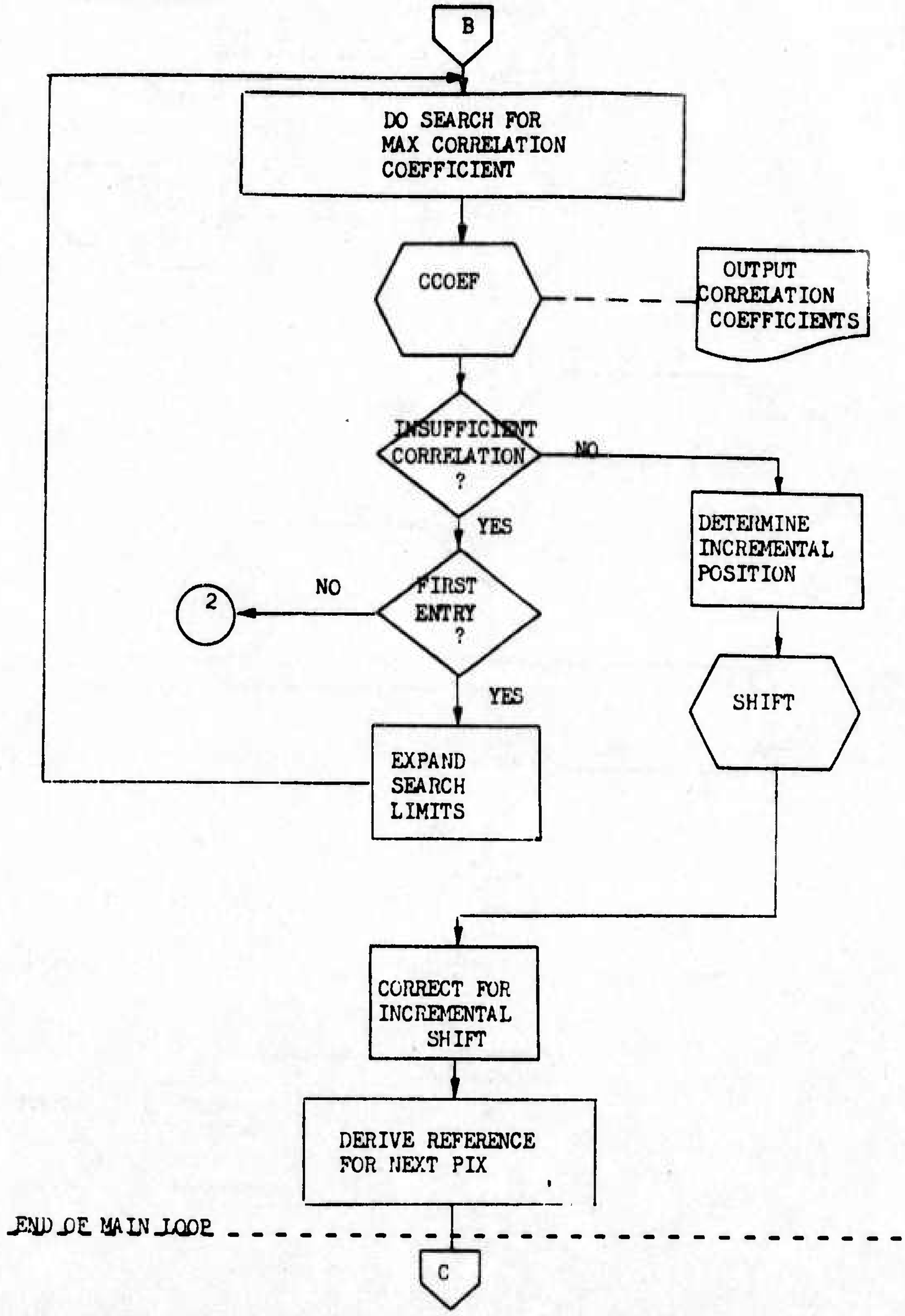


Figure 4. Referencing Program - Functional Flow Chart (3 of 4)

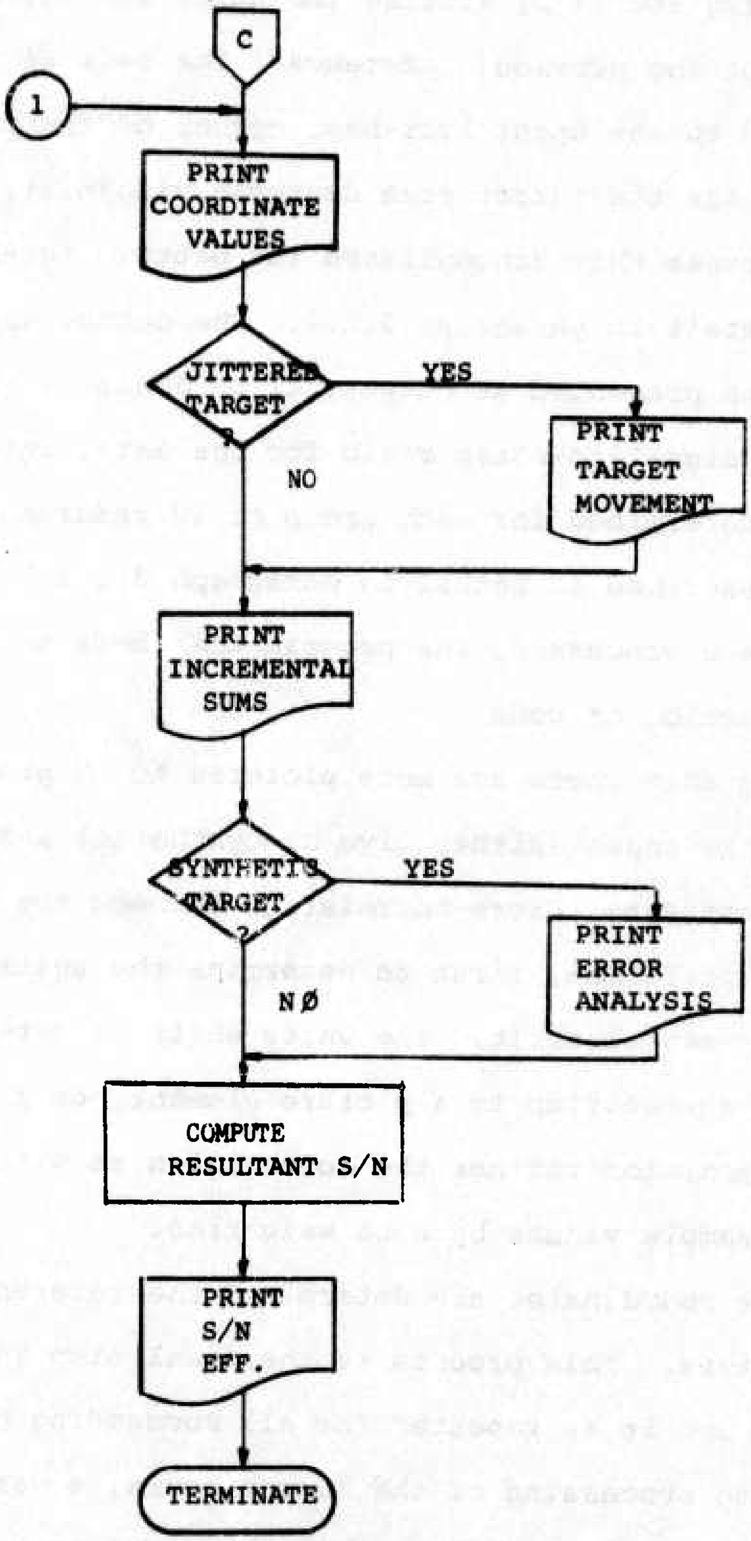


Figure 4. Referencing Program - Functional Flow Chart (4 of 4)

Processing starts by storing the units and incremental position values of the previous reference. The 64 x 64 output array is then moved to the upper left-hand corner of the picture. This output array has the target area centered within it. The incrementation process that accomplishes the pattern movement is described in detail in paragraph 3.1.2. The output array is then normalized and presented as output, if so desired. In order to estimate the signal-to-noise ratio for the data, intermediate samples are determined for each group of 10 references. This process is described in detail in paragraph 3.1.5.2. If all pictures have been processed, the program transfers to the analysis and output section of code.

Assuming that there are more pictures to be processed, the next picture is input (either live or synthetic) and converted to the proper contrast. Cross-correlation between the picture and reference is performed, first to determine the units shift and then the incremental shift. The units shift is determined by finding the peak correlation to a picture element, or pixel. The incremental position refines the correlation to within 1/16 of a pixel using sample values by area weighting.

Once the coordinates are determined the reference is derived from the picture. This process is the final step in the body of the program, and it is repeated for all succeeding pictures.

Following processing of the last picture, a variety of analyses and outputs are available. Print keys and target type direct the types of analyses that are done and the output that is produced.

3.1.5 Reference Program Performance on Synthetic Targets

The following sections present an overview of test target generation, the evaluation criteria, and performance on a number of test cases.

3.1.5.1 Synthetic Target Generation (Figure 5)

This routine requires some first pass, one-time processing. This branch of code reads in the target parameter data from cards. These data specify the target type, shape, and signal level. The target configuration and signal level are temporarily stored on some mass storage device. For the CDC 6600 a disk file is used.

If it is desired to modify the target signal level, this may be done by inputting a value on the data cards that will produce the desired value. For example, the signal level that is typically specified is 15 and the pattern that has been used through testing is an X-shaped pattern. This produces a target array (16 x 16) shown in figure 6. If a signal level of 10 is desired, rather than 15, then the input data scaling factor would be 0.66 and the target pattern would be stored as shown in figure 7.

This target, of course, is very unrealistic. A more representative pattern may be obtained by shaping the edges of the pattern. This process is accomplished using a filter that effectively produces a Gaussian taper to the edges of the target (see figures 8 and 9). This completes the preprocessing. The scaled-filtered target is stored on the disk file and every subsequent entry to the routine commences at this point.

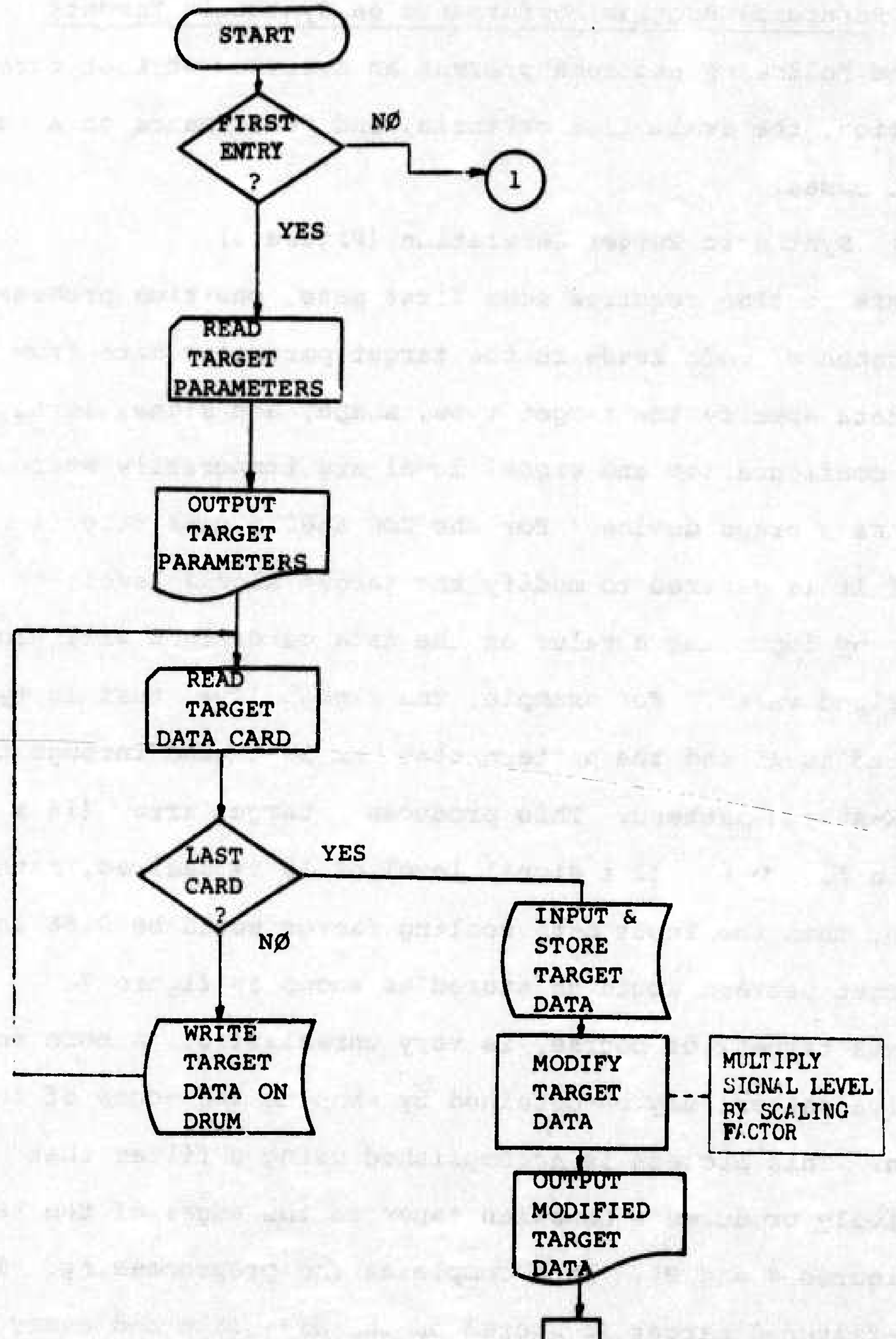


Figure 5. Synthetic Target Generator-Functional Flow Chart (1 of 2)

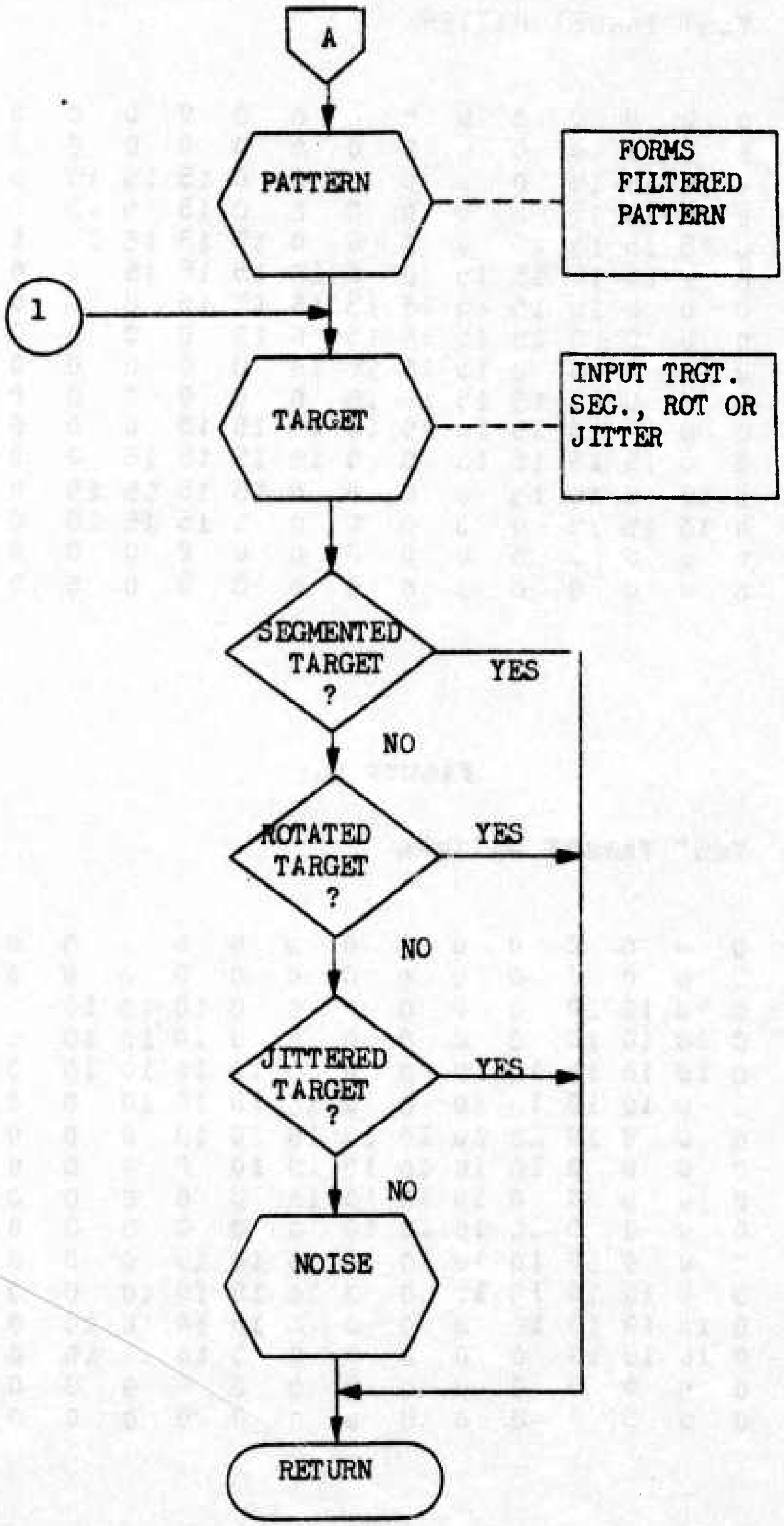


Figure 5. Synthetic Target Generator-Functional Flow Chart (2 of 2)

TEST TARGET PATTERN

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	15	15	15	0	0	0	0	0	0	15	15	15	0	0
0	0	15	15	15	0	0	0	0	0	0	15	15	15	0	0
0	0	15	15	15	15	0	0	0	0	15	15	15	15	0	0
0	0	0	15	15	15	15	0	0	15	15	15	15	0	0	0
0	0	0	0	15	15	15	15	15	15	15	15	0	0	0	0
0	0	0	0	0	15	15	15	15	15	15	0	0	0	0	0
0	0	0	0	0	0	15	15	15	15	0	0	0	0	0	0
0	0	0	0	0	15	15	15	15	0	0	0	0	0	0	0
0	0	0	0	15	15	15	15	15	15	15	15	0	0	0	0
0	0	0	15	15	15	15	0	0	15	15	15	15	0	0	0
0	0	15	15	15	15	0	0	0	0	15	15	15	15	0	0
0	0	15	15	15	0	0	0	0	0	0	15	15	15	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 6.

TEST TARGET PATTERN

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	10	10	10	0	0	0	0	0	0	10	10	10	0	0
0	0	10	10	10	0	0	0	0	0	0	10	10	10	0	0
0	0	10	10	10	10	0	0	0	0	10	10	10	10	0	0
0	0	0	10	10	10	10	0	0	10	10	10	10	0	0	0
0	0	0	0	10	10	10	10	10	10	10	10	0	0	0	0
0	0	0	0	0	10	10	10	10	10	10	0	0	0	0	0
0	0	0	0	0	0	10	10	10	10	0	0	0	0	0	0
0	0	0	0	0	10	10	10	10	0	0	0	0	0	0	0
0	0	0	0	10	10	10	10	10	10	10	10	0	0	0	0
0	0	0	10	10	10	10	0	0	10	10	10	10	0	0	0
0	0	10	10	10	10	0	0	0	0	10	10	10	10	0	0
0	0	10	10	10	0	0	0	0	0	0	10	10	10	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 7.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	10	10	10	0	0	0	0	0	0	10	10	10	0	0
0	0	10	10	10	0	0	0	0	0	0	10	10	10	0	0
0	0	10	10	10	10	0	0	0	0	10	10	10	10	0	0
0	0	0	10	10	10	10	0	0	10	10	10	10	0	0	0
0	0	0	0	10	10	10	10	10	10	10	10	0	0	0	0
0	0	0	0	0	10	10	10	10	10	10	0	0	0	0	0
0	0	0	0	0	0	10	10	10	10	0	0	0	0	0	0
0	0	0	0	0	10	10	10	10	0	0	0	0	0	0	0
0	0	0	0	10	10	10	10	10	10	10	10	0	0	0	0
0	0	0	10	10	10	10	0	0	10	10	10	10	0	0	0
0	0	10	10	10	10	0	0	0	0	10	10	10	10	0	0
0	0	10	10	10	0	0	0	0	0	0	10	10	10	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 8. Unfiltered Target Pattern

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	2	1	0	0	0	0	0	0	1	2	1	0	0
0	1	6	8	6	1	0	0	0	0	1	6	8	6	1	0
0	2	8	10	8	3	0	0	0	0	3	8	10	8	2	0
0	1	7	9	9	7	2	0	0	2	7	9	9	7	1	0
0	0	2	7	9	9	7	3	3	7	9	9	7	2	0	0
0	0	0	2	7	9	9	8	8	9	9	7	2	0	0	0
0	0	0	0	2	7	9	10	10	9	7	2	0	0	0	0
0	0	0	0	1	4	9	10	9	7	2	0	0	0	0	0
0	0	0	0	2	7	9	10	9	4	2	1	0	0	0	0
0	0	0	2	7	9	9	8	8	8	8	7	2	0	0	0
0	0	2	7	9	9	7	3	3	7	9	9	7	2	0	0
0	1	7	9	9	7	2	0	0	2	7	9	9	7	1	0
0	1	6	8	7	2	0	0	0	0	2	7	8	6	1	0
0	0	1	2	1	0	0	0	0	0	0	1	2	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 9. Filtered Target Pattern

Consider a 100 x 100 picture matrix initially set to zero. Since noise may be added to the picture, and the lower limit pixel value is 0, this would not allow for any negative noise contributions. In order to allow for the greatest dynamic range the pixel values are initially set at 32.

Target data is read from the disk file and the signal is added into the appropriate pixel positions. However, if the target is to be segmented, rotated or jittered, these processes are performed prior to the actual additions.

If the target is altered, noise is not added to the picture. Otherwise, normally distributed random noise is added to the entire picture. This process completes the generation of a synthetic picture.

3.1.5.2 Effective Signal to Noise Ratio

To obtain an estimate of the performance of the referencing program on arbitrary data, a signal to noise measure is developed for the given pattern data and comparisons are made with performance on known, synthetic patterns at the same signal to noise ratio.

The effective signal to noise ratio, SNR_e, is defined as the ratio of rms <u>signal modulation</u> to rms noise. Both of the above parameters must be estimated from the given data and the procedures are as follows:

Each input pattern is given by an n x n matrix P^k; K = 1,... m. The value m is the number of successive frames over which data is taken. (For typical data, correlation of the data is

assumed high for perhaps 10 frames and m is taken as 10.) The mean pattern, $\overline{P}$, is given by

$$\overline{P} = \frac{1}{m} \sum_{k=1}^{m} P^k \tag{86}$$

The mean intensity value, I_o, is defined as the mean of the $\overline{P}$ values

$$I_o = \frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} \overline{P}_{ij} . \tag{87}$$

Given the mean intensity, a signal modulation matrix, S, is defined by

$$S_{ij} = \overline{P}_{ij} - I_o . \tag{88}$$

With the above definitions, the rms signal modulation, V, is defined by

$$V = \sqrt{\frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} S_{ij}^2} . \tag{89}$$

Equivalently,

$$V = \sqrt{\frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} (\overline{P}_{ij})^2 - I_o^2} . \tag{90}$$

The per element noise value, δ_{ij}^2, is estimated by

$$\sigma_{ij}^2 = \frac{1}{m} \sum_{k=1}^{m} (P_{ij}^k - \overline{P}_{ij})^2 , \tag{91}$$

or

$$\sigma_{ij}^2 = \frac{1}{m} \sum_{k=1}^{m} (P_{ij}^k)^2 - (\overline{P}_{ij})^2 . \tag{92}$$

The noise value, σ_o, is given by

$$\sigma_o = \sqrt{\frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_{ij}^2} \quad . \tag{93}$$

Finally, the effective signal to noise ratio, SNR_e, is given by

$$SNR_e = V/\sigma_o . \tag{94}$$

3.1.6 Reference Program Evaluation

In the initial treatment of reference program performance (see R&D Status Report No. 3), the process was treated as a stationary one and the statistics of variance (jitter) and drift were obtained from a linear regression analysis. The reference process, however, is more complex and is in fact stochastic. Examination of the data against synthetic test targets indicates that for each sample, the x and y values are incremented or decremented by a value δ which depends on the effective signal-to-noise ratio. The track point walks randomly on the error plane making excursions at 45-, -45-, 135- or -135-degree angles over a distance of $\sqrt{2}\,\delta$ at each step. A typical walk of this type is shown in figure 10.

Since the perturbations are square waves (or nearly so) the variance in each axis is δ^2 and the radial jitter is $\sqrt{2}\,\delta$ units rms. The δ values are shown in figure 11 plotted versus effective signal-to-noise ratio; the values were obtained from a 50-sample test with an "X" target.

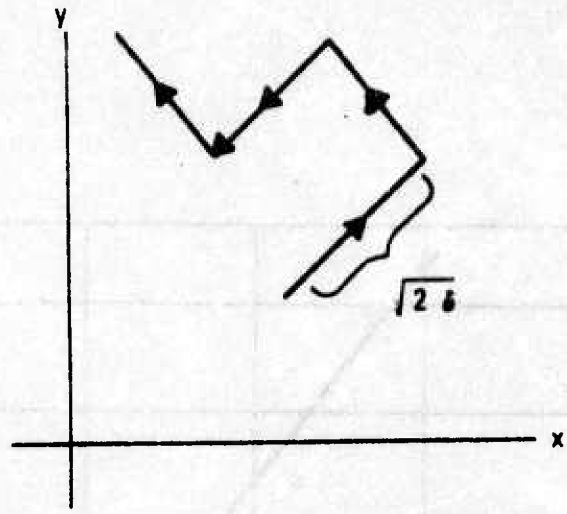


Figure 10. Random Walk of Track Point

The drift experienced during any given test may not be representative and a number of 50-sample runs at a given signal-to-noise ratio would have to be made to obtain an average drift value. With an average time of 250 seconds of computer time on the CDC 6600 for each 50-sample run, such a test is expensive and impractical. However, the approximate random walk behavior can be modeled, and estimates of the mean drift can be made.

The analysis initially considers x-distance drift. The form for the y-axis is identical and is ultimately combined with the x-value to compute a radial drift distance value. The process occurs over n-stages where n is assumed even.

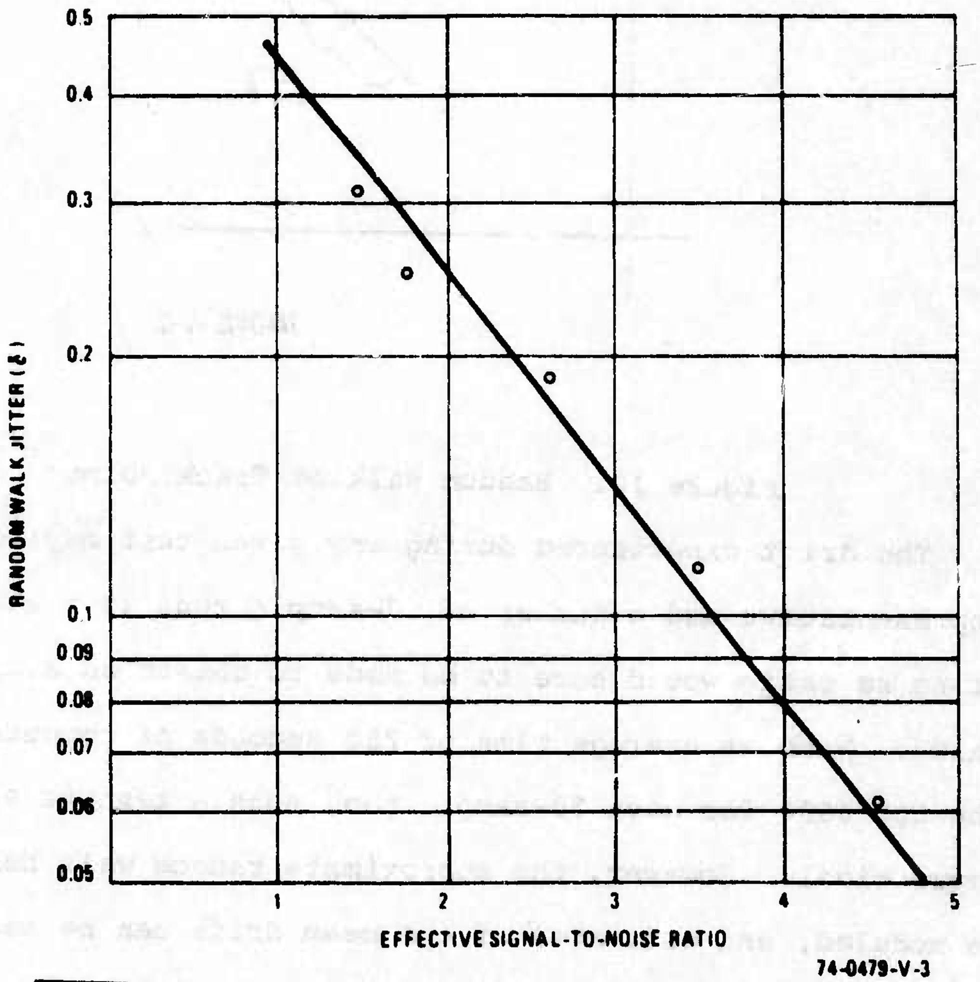


Figure 11. Random Walk Jitter Value δ vs. Effective Signal-to-Noise Ratio

At each stage of the process, the accumulated x-distance increases to $x+\delta$ with probability $\frac{1}{2}$ or decreases to $x-\delta$ with probability $\frac{1}{2}$. For an n-stage process, the x-displacement is $K\delta$ where $-n \leq k \leq n$.

Let $$x = k\delta \tag{95}$$

If $k>0$ then there must be k more positive transitions than negative transitions over the n-steps.

Let u = number of positive transitions

v = number of negative transitions

The sum must equal n:

$$u + v = n \tag{96}$$

The difference must equal k:

$$u - v = k \tag{97}$$

These simple equations imply that

$$u = \frac{n+k}{2} \tag{98}$$

$$v = \frac{n-k}{2} \tag{99}$$

Since u and v are integers and n is assumed even, then k must be even.

Now

$$\text{Prob}\left\{x = k_{\delta}\right\} = \text{Prob}\left\{\begin{matrix}\text{u successes in}\\ \text{n Bernoulli trials}\end{matrix}\right\}$$

The last probability value is given by the binomial distribution; i.e.,

$$\text{Prob}\ \{k \text{ successes in } n \text{ trials with probability } p \text{ of a success}\}$$

$$= \binom{n}{k} p^{k} (1-p)^{n-k} \tag{100}$$

where

$$\binom{n}{k} = \frac{n!}{(n-k)!k!} \tag{101}$$

For the given problem, $p = ½$ and

$$\text{Prob}\ \{x = k\delta\} = \binom{n}{\frac{n+k}{2}} (½)^{n} \tag{102}$$

$$k=0, \pm 2, \pm 4, \ldots, \pm n$$

Let E( ) be the expectation operator.

Then

$$E(x) = \sum_{m=-n/2}^{n/2} 2m\delta \binom{n}{\frac{n}{2}+m} (½)^{n} \tag{103}$$

An identity gives $\binom{n}{k} = \binom{n}{n-k}$ (104)

$$\binom{n}{\frac{n}{2}+m} = \binom{n}{n-\frac{n}{2}-m} = \binom{n}{\frac{n}{2}-m} \tag{105}$$

From equations (103) and (105),

$$E(x) = 0. \tag{106}$$

The variance of x equals $E(x^2)$ since $E(x) = 0$.

$$E(x^2) = \sum_{m=-n/2}^{n/2} 4m^2\delta^2 \binom{n}{\frac{n}{2}+m} (\tfrac{1}{2})^n \tag{107}$$

Let

$$k = m+\frac{n}{2} \tag{108}$$

or

$$m = k-\frac{n}{2} \tag{109}$$

$$E(x^2) = \sum_{k=0}^{n} 4(k-n/2)^2\delta^2 \binom{n}{k} (\tfrac{1}{2})^n \tag{110}$$

Now

$$\sum_{k=0}^{n} \binom{n}{k} (\tfrac{1}{2})^n = 1$$

$$\sum_{k=0}^{n} k\binom{n}{k} (\tfrac{1}{2})^n = \frac{n}{2} \tag{111}$$

$$\sum_{k=0}^{n} k^2\binom{n}{k} (\tfrac{1}{2})^n = \frac{n+n^2}{4}$$

From equations 110 and 111,

$$E(x^2) = n\delta^2 \tag{112}$$

For n large, the binomial form can be approximated by a continuous normal density with the same mean and variance; hence, for the given case, the approximate density for the x process, $f(x,n)$ is given by

$$f(x,n) = \frac{1}{\sqrt{2\pi n}\,\delta} e^{-\frac{x^2}{2n\delta^2}} \tag{113}$$

An identical process occurs for the y axis such that

$$f(y,n) = \frac{1}{\sqrt{2\pi n\delta}} e^{-\frac{y^2}{2n\delta^2}} \qquad (114)$$

For the two assumed independent random processes X(n) and Y(n), the drift radius R(n) is given by

$$R(n) = \sqrt{X^2(n) + Y^2(n)} \qquad (115)$$

The density for this random variable is Rayleigh and is given by

$$g(r,n) = \frac{r}{n\delta^2} e^{-\frac{1}{2}\left(\frac{r}{\sqrt{n}\delta}\right)^2} \qquad (116)$$

Finally, the mean drift radius $\overline{r}(n)$ is determined from the Rayleigh distribution mean as

$$\overline{r}(n) = \sqrt{\frac{\pi n}{2}}\,\delta \qquad (117)$$

For n = 50

$$\overline{r}(50) = 8.862\delta \qquad (118)$$

Further,

$$Pr\left\{r \leq x\right\} = \int_0^x \frac{r}{n\delta^2} e^{-\frac{1}{2}\left(\frac{r}{\sqrt{n}\delta}\right)^2} dr \qquad (119)$$

$$Pr\left\{r \leq x\right\} = \int_0^x -\frac{d}{dr}\left(e^{-\frac{1}{2}\left(\frac{r}{\sqrt{n}\delta}\right)^2}\right) dr = 1 - e^{-\frac{1}{2}\left(\frac{x}{\sqrt{n}\delta}\right)^2} \qquad (120)$$

Given some probability p, the value of x is given by

$$x = \delta\sqrt{-2n \ln (1-p)} \qquad (121)$$

For n=50 and p=0.99

$$x = 21.46\delta \qquad (122)$$

or for 50 samples, the drift radius is less than 21.46 δ with 99 percent probability. The mean and 99 percent probability drift values are plotted versus effective signal-to-noise ratio in figure 12.

3.2 TRACK PROGRAM

The following paragraphs detail the general method employed in the track program. In particular, a Monte Carlo procedure and channel gain normalization are discussed. An overview of program organization is discussed at the end of this section.

3.2.1 Monte Carlo Method

The sequence of input images to the track program is rendered virtually motionless by the operation of the Referencing Program. Except for small geometric perturbations, operations on this set of static images would produce good results for all tracker configurations since each would operate at a null position. As will be shown, the centroid and edge track performance is pattern dependent, and an indication of true displacement error depends upon the target pattern (or the portion of it) appearing within the track window. In a real situation, input disturbances and tracking noise cause the target to translate relative to the position of the track window, ultimately causing the gimbal servo to correct for these errors. These disturbances can be of limited magnitude (so as to prevent "unlock" conditions) and in any direction. To simulate this condition, the referenced images are randomly displaced by known amounts and then operated on by the trackers. Numbers are chosen in integer values from a uniform random number

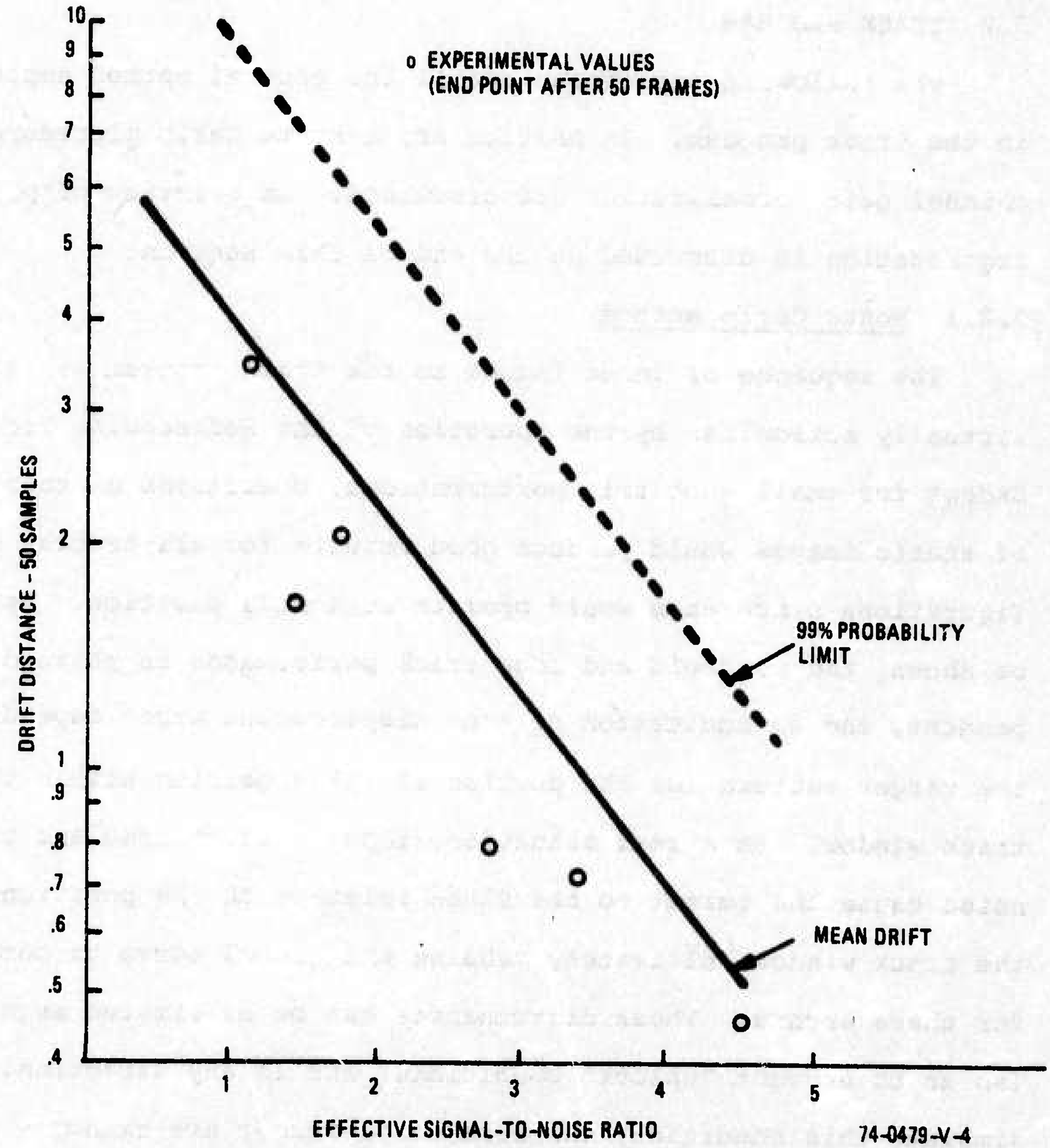


Figure 12. Drift Distance (Calculated) vs. Effective Signal-to-Noise Ratio

generator included as a subroutine in the track program. Over a long run, the trackers are caused to determine displacement errors over many of the various target regions each chosen at random. The use of random rather than programmed displacements does not bias the results since all possible directions occur at all disturbance frequencies (approximating a "white" noise disturbance spectrum). Since the disturbances are known, they can be accounted for in the determination of tracker error; a perfect tracker would indicate displacement errors equal to the actual displacements. The actual tracker performance is not perfect, however, due to noise, geometric perturbations, and nonlinear channel gain (edge and centroid trackers). The effects of nonlinear gain are covered in the next section.

3.2.2 Normalization of Output Data

In order to compare the performance of each of the tracker configurations, the channel gains have to be normalized. That is, as an error measurement element, each tracker has a certain error gain in terms of indicated displacement versus actual displacement. For targets which are totally enclosed within the track window, the relative gain is unity for all configurations; however, for targets which extend through the window, the edge and centroid trackers will indicate a relative gain of less than unity. This is shown by the simple example illustrated in figure 13.

The object in figure 13b is displaced one unit to the left of the same object in figure 13a. Biased measures are used for

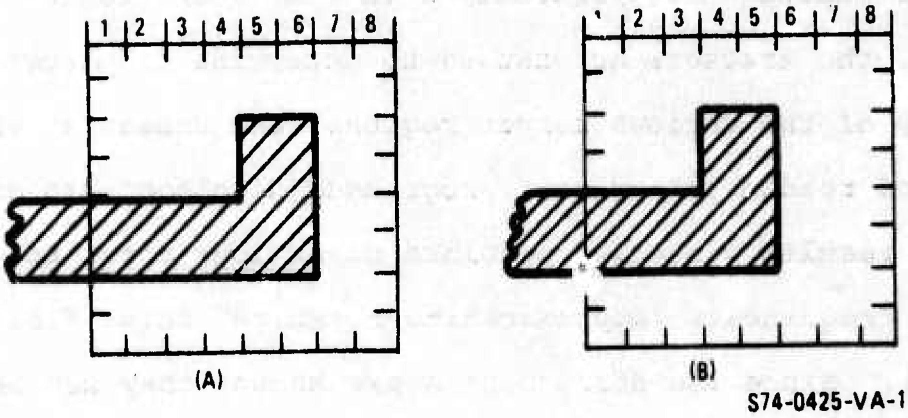


Figure 13. Sample Target Positions

the edge and centroid tracker so that the change in measured position indicates the track error.

For figure 13a,

$$\overline{x}_a = [2(1) + 2(2) + 2(3) + 2(4) + 4(5) + 4(6)]/16 = 4.0.$$

For figure 13b,

$$\overline{x}_b = [2(1) + 2(2) + 2(3) + 4(4) + 4(5)]/14 = 3.4286.$$

Track error = $\Delta x = \overline{x}_b - \overline{x}_a = -.5714$.

Effective channel gain = .5714 (actual displacement = -1.0).

In general, the channel gain is pattern dependent. Now suppose that in a sequence of samples, an observation of track measurement y_n is made for sample n. The measurement y_n is determined as follows:

$$y_n = Gx_n + \epsilon_n \tag{123}$$

where G = channel gain

x_n = input displacement

ϵ_n = measurement error.

The tracker error for sample n, γ_n, is the difference between the observed and input displacements; that is,

$$\gamma_n = y_n - x_n = x_n(G - 1) + \varepsilon_n \tag{124}$$

As shown, when the gain G is not unity, the error indicates both input displacements and output error. This situation is remedied by normalizing the observations to obtain $\hat{y}_n$ instead of y_n:

$$\hat{y}_n = \frac{y_n}{G} = x_n + \frac{\varepsilon_n}{G} \tag{125}$$

$$\hat{\gamma}_n = \hat{y}_n - x_n = \frac{\varepsilon_n}{G} \tag{126}$$

The results as given by equations (124) or (126) are compared as follows.

The input displacements x_n are assumed to be random variables with zero mean and variance $\sigma_x{}^2$. The displacements are also assumed to be independent of the measurement errors, ε_n, which have variance $\sigma_\varepsilon{}^2$. With the above definitions, the error variances are given by

$$\mathrm{Var}(\gamma) = (G - 1)^2\sigma_x{}^2 + \sigma_\varepsilon{}^2 \tag{127}$$

and

$$\mathrm{Var}(\hat{\gamma}) = \frac{1}{G^2}\,\sigma_\varepsilon{}^2 \tag{128}$$

The ratio of rms errors, r, is defined by

$$r = \sqrt{\frac{\mathrm{Var}(\hat{\gamma})}{\mathrm{Var}(\gamma)}} \tag{129}$$

Define

$$\rho = \frac{\sigma_\varepsilon}{\sigma_x} = \frac{\text{output rms error}}{\text{input rms displacement}} \tag{130}$$

Then,

$$r = \frac{1}{G\sqrt{(G-1)^2\rho^2 + 1}} \tag{131}$$

This function is plotted in figure 14. The following conclusions may be drawn from the plots:

a. When ρ is small, indicating that the tracker is effectively reducing the input displacement (that is, closely tracking position displacements), the error indicated by equation (124) may actually be greater than the true error for low channel gains.

b. For moderate displacement reductions and low channel gain, the error indicated by equation (124) is much smaller than actual values.

c. For channel gains in excess of .5 and moderate reduction ($\rho =$ .35) either equation (124) or equation (126) is applicable.

To avoid ambiguities in the assessment of relative tracker performance, the form of equation (126) is used. However, the gain G is unknown (except for the correlation tracker where G = 1) and is pattern dependent. Because G is pattern dependent, it can not be measured directly but can be estimated as follows.

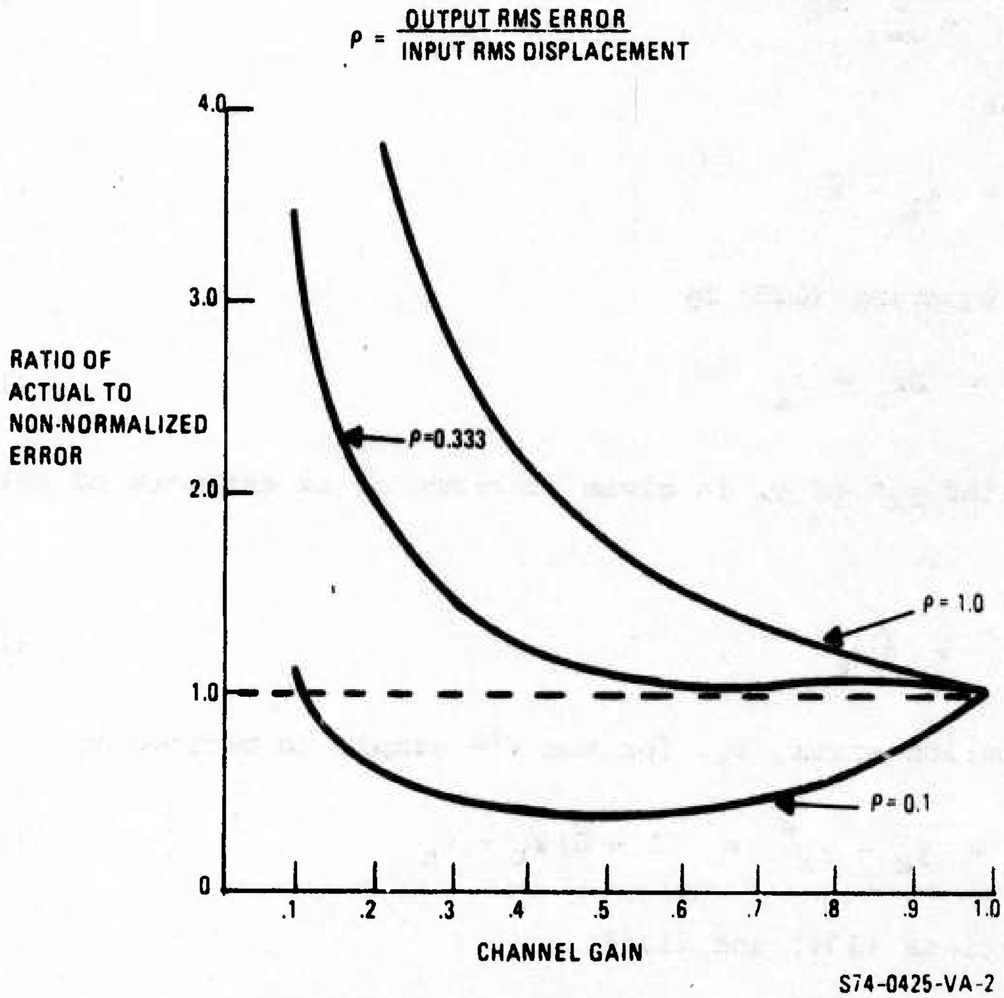


Figure 14. Ratio of Actual to Observed Error

Suppose that n samples comprise a tracking run. For a finite number of samples the input displacements may not have zero mean. A zero mean displacement z_k is defined as follows. Let

$$\bar{x} = \frac{1}{n} \sum_{k=1}^{n} x_k \tag{132}$$

and define

$$z_k = x_k - \bar{x} \tag{133}$$

Redefine equation (123) by

$$y_k = Gz_k + \varepsilon_k \tag{134}$$

An estimated y_k^* of y_k is given in terms of an estimate of the gain, $\hat{G}$,

$$y_k^* = \hat{G} z_k \tag{135}$$

The estimation error, β_k, for the k^{th} sample is defined by

$$\beta_k = y_k - y_k^* = (G - \hat{G}) z_k + \varepsilon_k \tag{136}$$

From equations (134) and (136),

$$\beta_k = - \hat{G} z_k + y_k \tag{137}$$

Now, $\hat{G}$ is estimated by minimizing the mean square error; i.e.,

$$\beta = \sum_{k=1}^{n} \beta_k^2 = \hat{G}^2 \sum_{k=1}^{n} z_k^2 - 2\hat{G} \sum_{k=1}^{n} y_k z_k + \sum_{k=1}^{n} y_k^2 \tag{138}$$

The derivative of β with respect to $\hat{G}$ is

$$\frac{d\beta}{d\hat{G}} = 2\hat{G} \sum_{k=1}^{n} z_k^{\,2} - 2 \sum_{k=1}^{n} y_k z_k \tag{139}$$

Setting the derivative equal to zero and solving for $\hat{G}$ gives

$$\hat{G} = \frac{\sum_{k=1}^{n} y_k z_k}{\sum_{k=1}^{n} z_k^{\,2}} \tag{140}$$

Finally, in terms of the initially measured quantities,

$$\hat{G} = \frac{\sum_{k=1}^{n} y_k (x_k - \bar{x})}{\sum_{k=1}^{n} (x_k - \bar{x})^2} \tag{141}$$

3.2.3 Data Evaluation

Data for all trackers are collected during a run and then processed (after channel gain correction) by a simulated servo loop filter (Refer to Appendix IV for specific forms). The simulation is open loop and provides results equivalent to closed loop performance provided that the resultant track errors are small. The evaluation is made on track point jitter and track point drift. Since the simulation is open loop, the effects of drift are minimized in the recorded data for the centroid and edge trackers since the target always appears at a nominal zero position (that is, for a long run, the mean of the target displacements approaches zero since the displacements are derived from a uniform population which is symmetric about zero). For a closed-loop simulation, any drift in the edge of centroid trackers would result in the measure

of a constantly changing position on the target. On the other hand, the correlation tracker reflects the effects of drift through the reference update routine which assumes a new target position if a drift occurs.

3.2.4 Tracking Computer Program Overview

The tracking program is the portion of the Computer Simulation Package designed to simulate the operations of various video tracking algorithms and methods and determine the resultant tracking error signals. Tracking is performed on a frame to frame basis on video data prepared by the Referencing Program.

The program performs, simultaneously, edge, centroid, and correlation tracking, with various options for each type. The video data input consists of 64- x 64-element digitized pictures (frames) read from a magnetic tape. The first frame read forms a reference point from which the tracking operations begin. The tracking is performed using a 32- x 32-element window from the input frame, and this window is shifted from frame to frame to produce target offsets. X- and Y-axis tracking errors for each of the three tracking methods are accumulated frame by frame, and these signals are used to compute statistical data after all frames have been processed. Outputs from a run include the error signals, the signals after filtering, their mean, rms, and regression coefficients, and a tabulation and plot of the spectral density of each signal.

Program features include the following:

a. Centroid tracking is accomplished by computing the centroid of a 16- x 16-element target window derived from the video input data window. It can be either a binary pattern, or the original pattern with elements below an input threshold zeroed, depending on an input option. The bias from the first frame (the reference frame) is removed from all subsequent frames.

b. Edge tracking is accomplished in a manner similar to centroid tracking, but the input frame is first exposed to a video differentiator. The differentiated data is thresholded, yielding a binary pattern, which can then optionally be exposed to a thinning process.

c. Correlation tracking is accomplished by finding the location within the 32- x 32-element input window which has the highest correlation to a 16- x 16-element reference target. The initial reference matrix is extracted from the first frame processed, and the reference matrix is updated by one of three options. One method performs a recursive frame-to-frame update. The other methods update every n frames, skipping or averaging the data of the last n frames, where n is an input variable. Any of several different correlation computation schemes can be used, controllable by input. Preprocessing of the video input can be specified to use linear data, binary patterns, or linear data above a threshold.

d. Frame-to-frame target offsets can be either randomly generated (within specified limits) or taken from a table, representing the servo response to a transient, and scaled.

e. The number of bits of the video input data used can be specified by card input.

The following paragraph describes the main program.

3.2.5 <u>Main Program (VIDTRK) Figure 15</u>

The main program controls the flow between the various subroutines, performs input and output functions, and does much of the actual computation required for a run. A functional flow chart is shown in figure 15.

The program begins by reading card inputs to specify all run parameters and options. Next, the run conditions are printed.

If the input option IOFF specified frame-to-frame target offsets from a transient table this table is computed, using subroutine FILTER, and printed. Then certain initialization is performed and the indices of the input 32 x 32 submatrix from the input frame are computed from the target dimensions. The input tape is then positioned to the frame specified to begin processing.

At this point, a loop which contains most of the remainder of the program is entered. This loop is executed for each input frame processed.

In all but the first time through the loop, target offsets are generated either randomly or from the transient table. Since

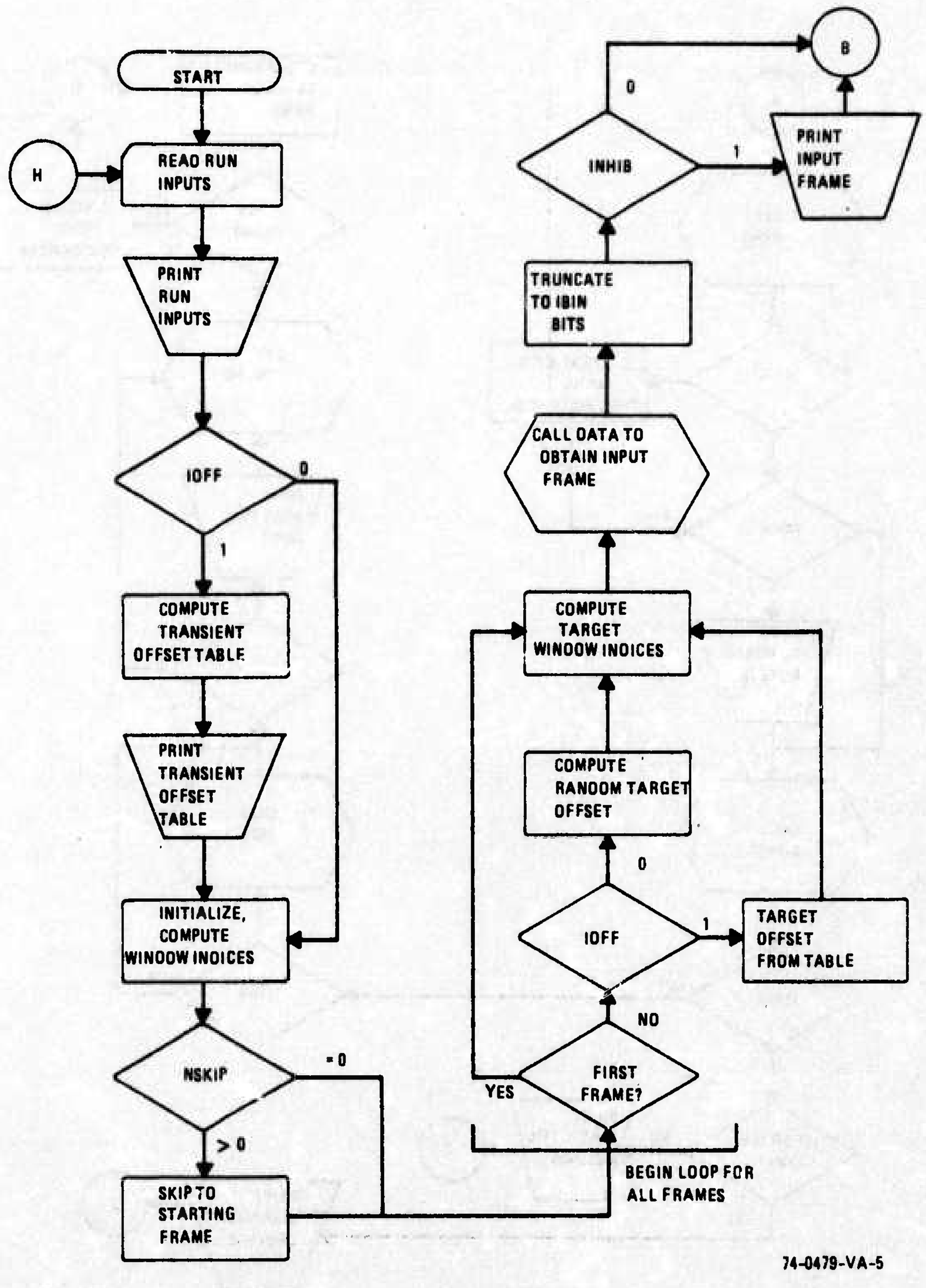


Figure 15. Tracking Program Functional Flow Chart (Sheet 1 of 5)

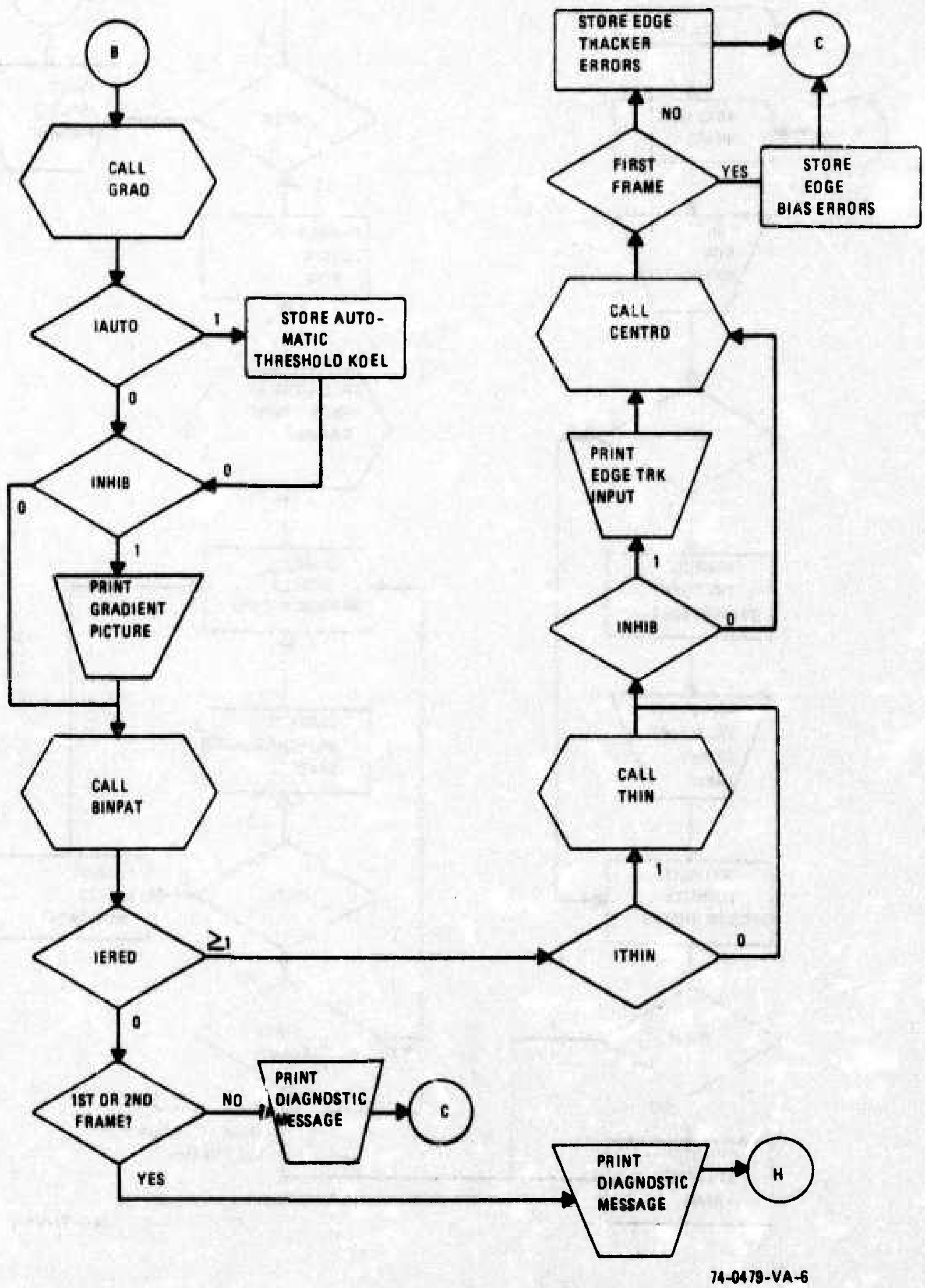


Figure 15. Tracking Program Functional Flow Chart (Sheet 2 of 5)

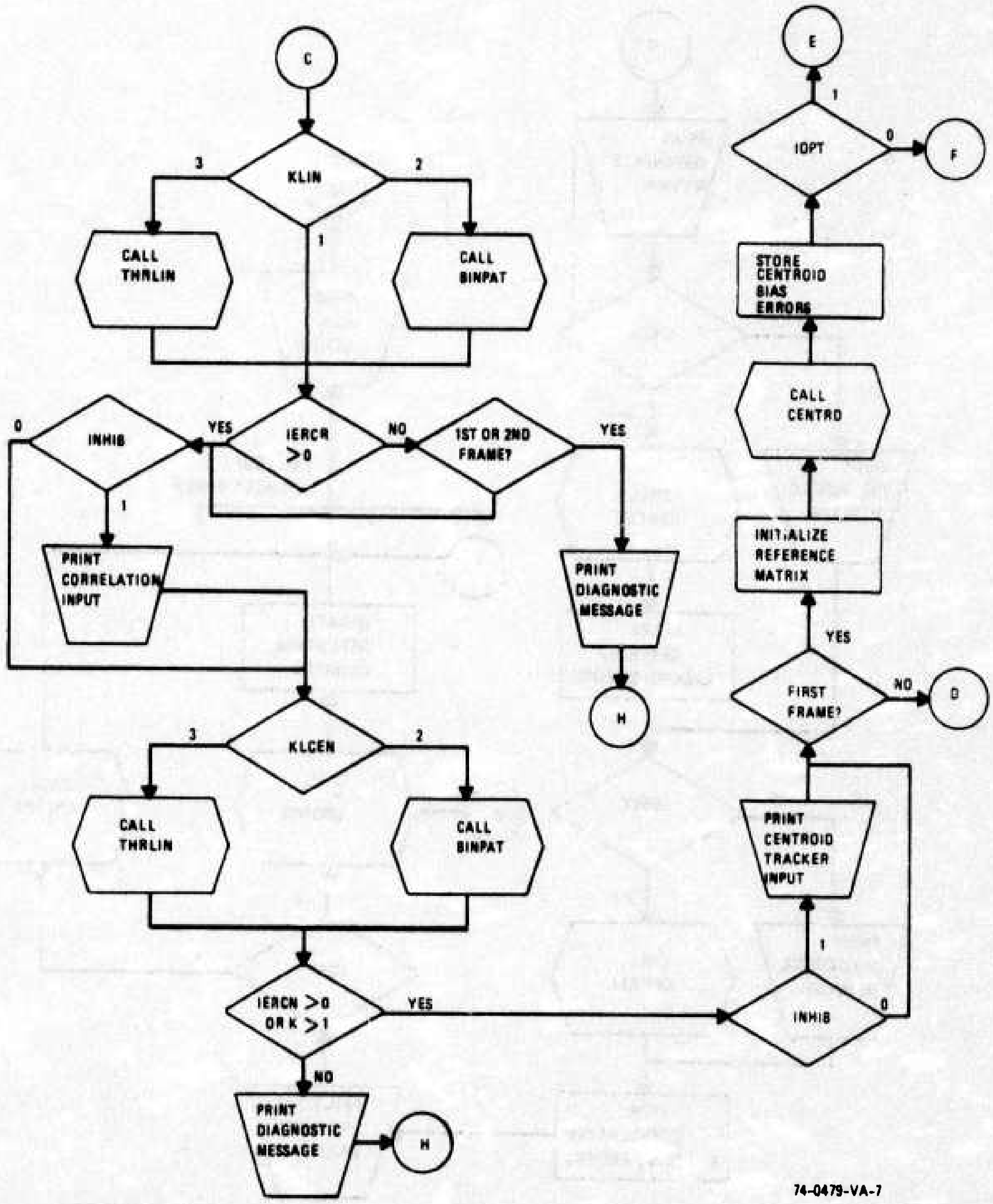


Figure 15. Tracking Program Functional Flow Chart (Sheet 3 of 5)

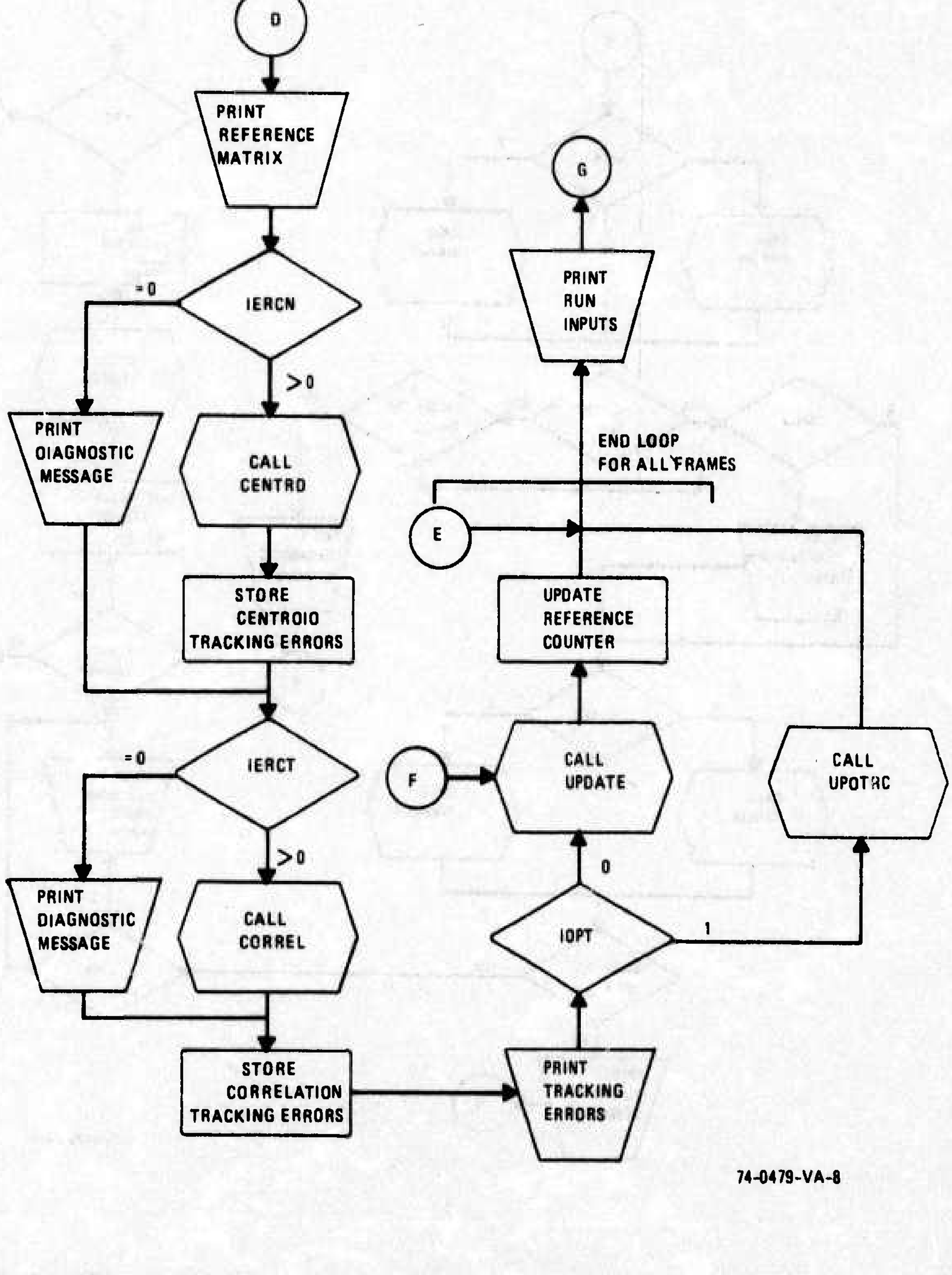


Figure 15. Tracking Program Functional Flow Chart (Sheet 4 of 5)

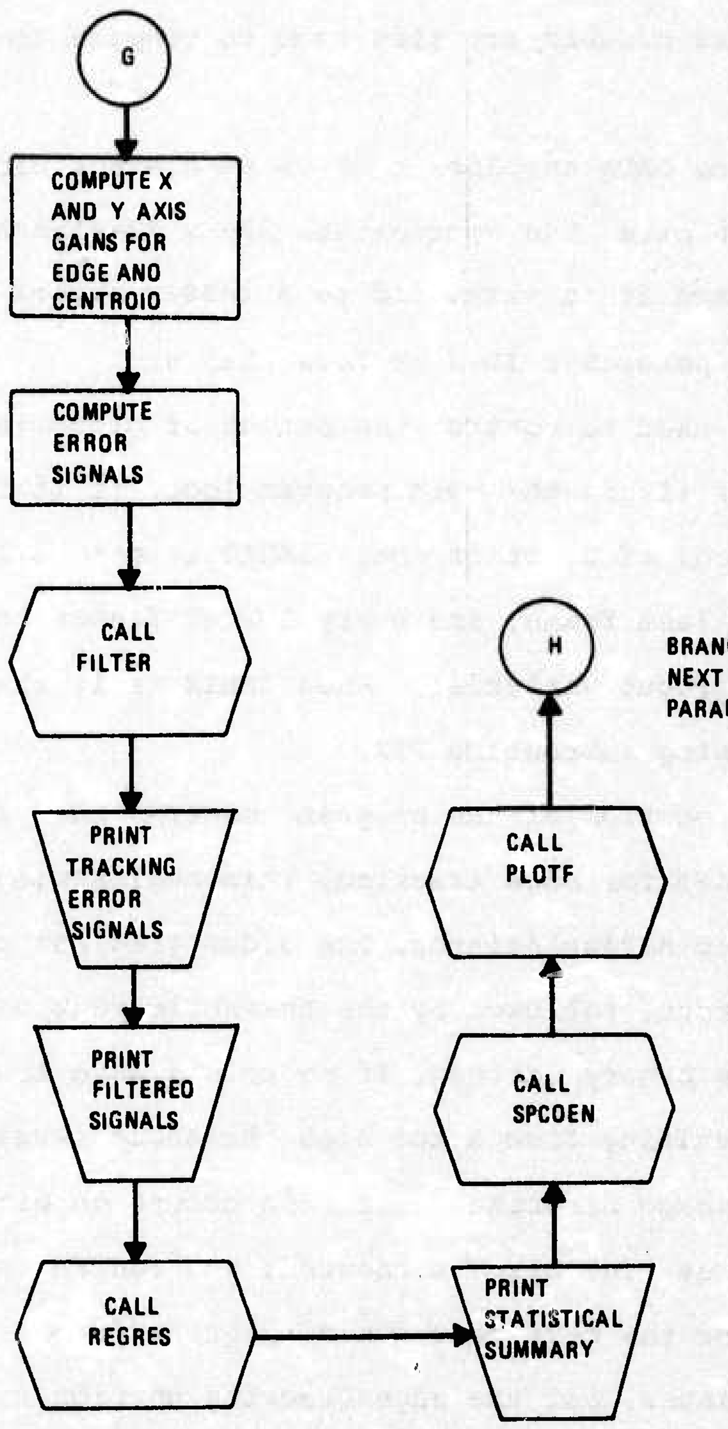


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Figure 15. Tracking Program Functional Flow Chart (Sheet 5 of 5)

the first frame forms a reference, or starting point, no offsets are used. These offsets are then used to compute the target window location.

Subroutine DATA supplies a 64- x 64-element video input frame digitized to 6 bits. The appropriate 32- x 32-element submatrix is extracted and it is truncated to a lesser number (IBIN) of bits if input parameter IBIN is less than 6.

INHIB is used to control the output of pictorial data at several points within the main program loop. If it is 1, the output is produced; if 0, it is not. INHIB is set to 1 for the first 2 frames, the last frame, and every IPRINT frames between. (IPRINT is an input variable.) When INHIB is 1, the input frame is printed, using subroutine PIX.

The next portion of the program concerns the preprocessing of the data used for edge tracking. This begins with subroutine GRAD, the video differentiator. The video gradient pattern is optionally output, followed by the threshold routine BINPAT, which yields a binary pattern. If no points were found above the threshold (resulting from a too high threshold level input), a diagnostic message is printed. If this occurs on either of the first two frames, the case is aborted, and control transfers to read inputs for the next case. On subsequent frames, execution of the case continues, but the edge tracking portion is skipped, and the tracking errors from the previous frame are used. The last step in edge track preprocessing is optional thinning (Subroutine THIN). This preprocessed data is then optionally printed out,

and CENTRD is called to determine the target location. On the first frame, the errors generated are stored as "bias" errors, to be subtracted from subsequent frames' errors.

The next portion of the program is the preprocessing of the correlation tracking data. Subroutine BINPAT is used if binary pattern processing is specified and THRLIN is used if linear above a threshold is specified. Cases where no elements above the threshold are found are handled exactly as for the edge tracker. This preprocessed data is optionally printed.

Following this is the preprocessing of the centroid tracker input, again using either BINPAT or THRLIN, just as for the correlation input, except that linear processing is not an allowable option.

If the first frame is being processed, the initial correlation reference matrix is extracted, and CENTRD is called to compute the initial bias errors which must be subtracted from subsequent centroid errors. Control is then transferred to either the end of the loop or to the updating routine UPDATE. (The recursive update routine, UPDTRC, is not called for the first frame.)

On other than the first frame, the correlation reference matrix IREF is printed, and subroutine CENTRD is called (unless no elements above the threshold were found) to perform the centroid tracking. Subroutine CORREL performs the correlation tracking computations unless no elements were found above the correlation threshold.

The X and Y tracking signals and errors are printed for each type of tracker. The signals labeled XM and YM are the raw signals generated and those labeled XC and YC are the remaining errors after the input frame offset and incremental errors are subtracted.

Finally, the correlation reference matrix IREF is updated by either subroutine UPDATE or UPDTRC. That ends the loop for each input frame to be processed. The remainder of the program is executed only once per case run.

The X- and Y-axis gains for the edge and centroid trackers are computed from the tracking signal and total target offset tables. The tracking error signal is then redefined as the difference between the tracking signal divided by the gain and the actual offsets. (The gain of the correlation tracker is one and is set to this value.)

The tracking errors thus computed are filtered by subroutine FILTER and the raw errors and filtered errors are printed out. Subroutine regress computes the mean, rms, and regression coefficient of each signal, and this statistical summary is output. Finally, subroutine SPCDEN computes the spectral density of each error signal and PLOTF produces a printer plot of the spectral densities.

That ends the processing of a case, and control is transferred to read in the input for the next case, if one exists.

SECTION IV

PREPARATION OF IMAGERY DATA

4.1 INTRODUCTION

This section details the methods used in the preparation of sequential image data for further operations performed by the reference and track programs. Each data type (TV or IR) is accommodated differently: the TV imagery is processed photographically prior to digitization; IR imagery is provided in digitized form and then digitally transformed for compatibility with the reference program.

4.2 TV IMAGE PROCESSING

4.2.1 TV Image Preparation - Digitization

After some experimentation, the following procedure was adopted for the preparation of TV data tapes. Imagery is first displayed on a monitor and recorded on 16 mm negative film. A light emitting diode array in front of the monitor is also photographed to display a time code for identification of the data frame. A "data" film is then made by using three strips of 7 sequential images placed side by side on a mask. A diagram of the mask is shown in figure 16. Using the size markers, the set of images is enlarged by 3:1 so that the rectangle defined by the size markers is 5 inches by 7 inches; enlargements are made on 8- by 10-inch negative film. The film is cut using the size markers

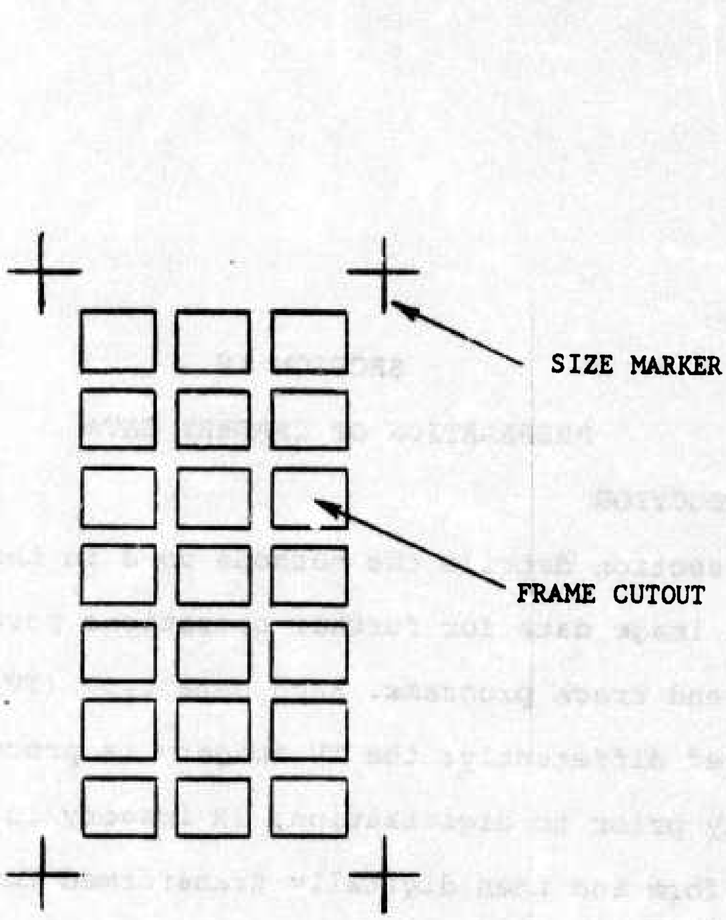

Figure 16. Film Preparation Mask

as guides and punched for placement in the photoscanner. Two holes near the top of the film provide the guide holes.

After the data film has been prepared, each frame is examined and a small pinhole is placed offset from the target. The photoscanner scans the data film vertically crossing the scan lines in the TV image at right angles to minimize Moiré effects. A machine language program was developed for the photoscanner to automate the process. In the first step of the process, the photoscanner scans the entire data film and finds and stores the pinhole locations. Scanning is performed with a 100-36μm beam and film density data is measured with 8-bit quantization. In the second step of the process, the photoscanner retraces its steps until it locates

the first pinhole. Using this point as a reference, the intensity values over the 100 by 100 window are examined and a bias value is determined for use in optimally converting the 8-bit data to 6-bit data for recording on digital tape. The same steps are used for all pictures (21 or less) on the data film resulting in packed recordings of 100 by 100 pictures with 100-36μm picture elements (pixels) of 6 bits.

4.2.2 TV Imaging Processing - Compatible Tape Generation

A program was developed which processes digitized image tapes from the Westinghouse DDP-124 computer and generates a machine compatible output tape which interfaces with the referencing programs.

The sequence of processing operations for the CSP programs is shown in figure 17. From this diagram it can be seen that the conversion program uses the lab tape (DDP-124) directly. In general, this is not an unreasonable requirement. Occasionally, these tapes may exhibit compatibility problems, such as abnormal frame counts or parity errors. In this event, a copy program is employed which neglects these problems and produces a tape in the original format of correct frame count and parity with nominal alterations to the recorded data. The new tape copy is then used as input to the conversion program.

The conversion program is written in FORTRAN and is machine specific. However two versions of the program exist, one for the UNIVAC and one for the CDC 6600. It reads a binary tape from the

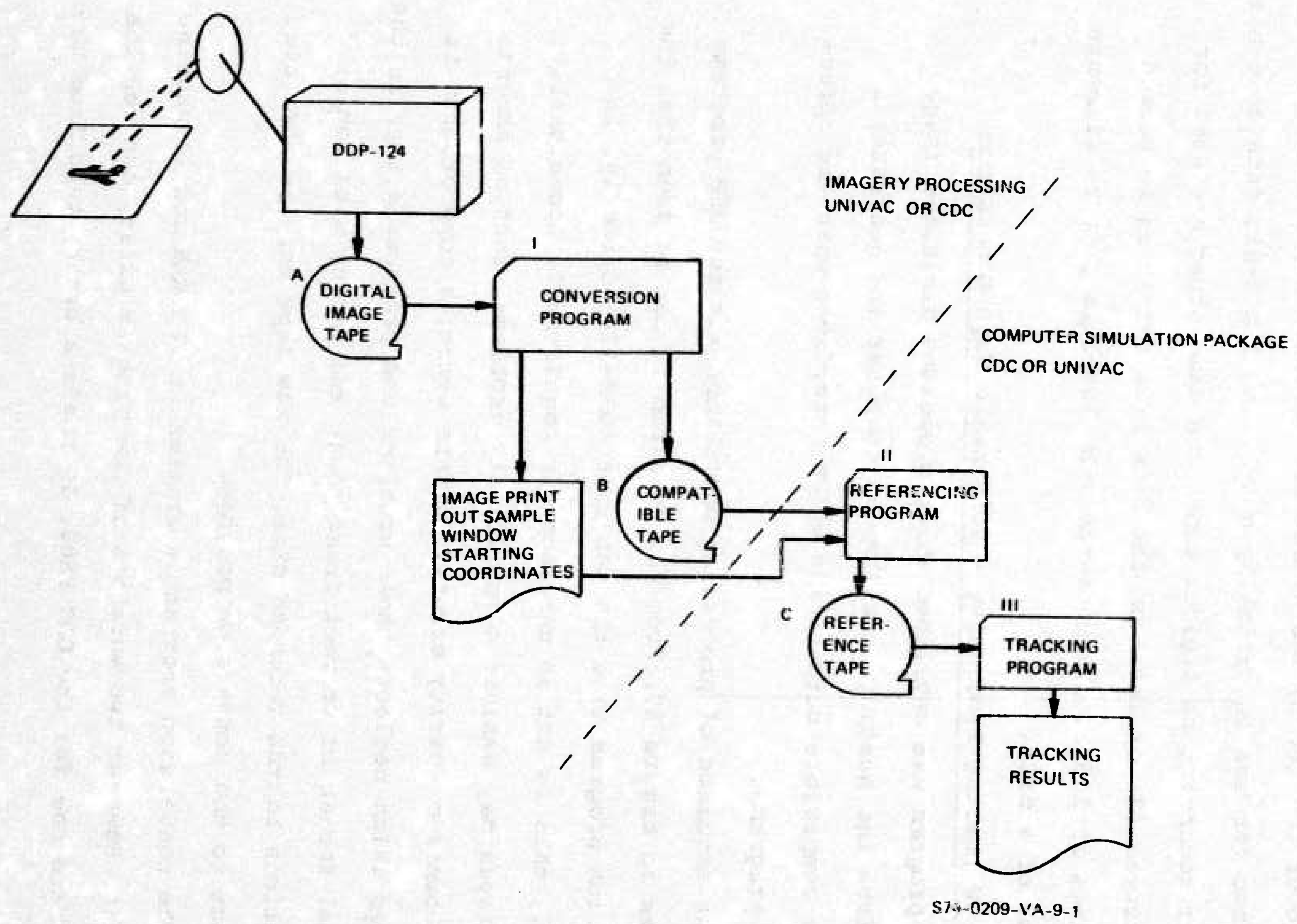

Figure 17. Sequence of Processing Operations

Honeywell DDP-124 and reformats the data onto a compatible BCD tape using FORTRAN I/O.

Table II gives a detailed description of TV image tape which is input to the conversion program. A program option permits usage of an alternative tape format which has interlaced files of images and track windows. The alternate tape format is shown in table III. In addition to the image tape, a data card input is required which contains program options and exercise title. The format of this card is given in table IV.

The compatible tape has 132 character records if produced on the UNIVAC and 100 character records if produced on the CDC. The tape is unlabeled. All of the information on the tape is contained in one file. Approximately 250 images may be output on one tape. On the CDC 6600, this tape is processed as an "X" or "S" tape. This designation on the REQUEST card is the only special requirement for using the compatible tape. Table V gives a summary description of all tapes in the CSP interface. Specific format of the compatible tape is shown in table VI.

A flow chart for the conversion program is given in figure 18. After producing the compatible tape, a quantized representation of the first image is printed which may be used to select the image reference points for intializing the referencing program.

Table II. Digital Image Tape Format (Tape A)

Parity: ODD
Density: 556 PBI
Unique I/O - Binary

NO.	NAME	DESCRIPTION	TYPE	SOURCE	UNITS
1-100		Image Record 18 words, 36 bits each, packed (108 samples - PIXELS, 6 bits each) First 100 PIXELS contain useful information 6-bit maximum value = 63 decimal Approximately 100 records per file (usually more than 100) First 100 contain useful information	I		Gray Value
	EOF	End of file (This sequence specifies a complete 100 x 100 image and is repeated for each image)			

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Table III. Digital Image Tape Alternate Format

Parity: ODD
Density: 556 BPI
Unique I/O - Binary

NO.	NAME	DESCRIPTION	TYPE	SOURCE	UNITS
1-100		Image Records 18 words, 36 bits each, packed First 100 PIXELS (6 BITS) useful info Approximately 100 records/file First 100 records useful info	I		Gray Value
	EOF	End of File			
101-150		Track Window Records 20 words, 36 bits each, packed Approximately 50 records/file First 50 records useful info			
	EOF	End of File (Track window files and image files are alternated on the tape. Usually image files are first.)			

S74-0209-3

Table IV. Data Card Input to Conversion Program

NO.	NAME	DESCRIPTION	CARD	FORMAT	UNITS	COLUMNS
1	ILACE	Indicator for interlaced files < 1 = No interlaced files, all files useful ≥ 1 = Every other file contains useful data (skip odd numbered files)	1	I5	-	1-5
2	NFILE	Number of images to reformat	1	I5	-	6-10
3	NWDIN	Number of words per record on input tape	1	I5	-	11-15
4	NWDOT	Number of words per record on output tape	1	I5	-	16-20
5	NREC	Number of records per image on output tape	1	I5	-	21-25
6	IMO	Month of tape generation	1	I5	-	26-30
7	IDAY	Day of tape generation	1	I5	-	31-35
8	IYR	Year of tape generation	1	I5 (15X)	-	36-40
9	EXNAME(I) I = 1,4	Exercise title	1	4A6	-	56-79

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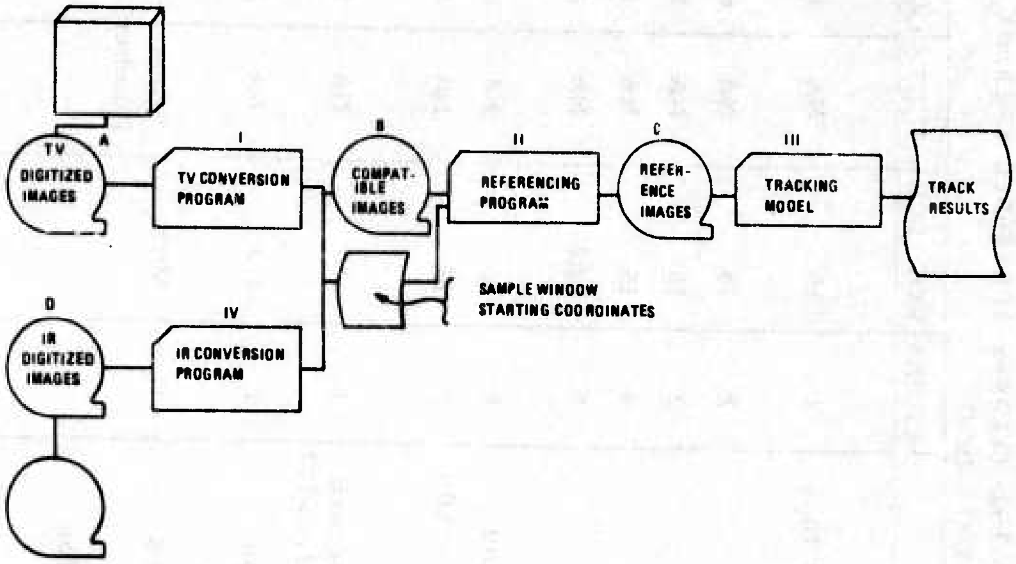
Table V. CSP Interface



TAPE	INTERFACE	SOURCE	TYPE	RECORDS	EOF	TRACKS	DENSITY	PARITY
A	DIGITIZED IMAGES TO CONVERSION PROGRAM (TV)	DDP-124	BINARY	18 WORDS, 36 BITS EACH	BETWEEN IMAGES (100 RECORDS)	7	556	ODD
B	CONVERSION PROGRAM TO REFERENCING PROGRAM	UNIVAC 1108 OR CDC 6600	BCD*	132 CHAR. UNIVAC 100 CHAR.-CDC	END OF INFO.	7	800	EVEN
C	REFERENCING PROGRAM TO TRACKING MODEL	UNIVAC 1108; CDC 6600	BINARY	UNFORMATTED	END OF INFO.	7	800	EVEN
D	DIGITIZED IMAGES TO CONVERSION PROGRAM (IR)	AF CDC 6600	BINARY	UNFORMATTED	BETWEEN IMAGES (3 RECORDS)	7	556	ODD

* UNIVAC BCD TAPES MAY BE READ ON CDC, BUT CDC BCD MAY NOT BE READ ON UNIVAC.

PROGRAM	FUNCTION	MACHINE	
I	STANDARDIZE DIGITAL TAPE (TV)	UNIVAC 1108; CDC 6600	
II	REFERENCE IMAGES	UNIVAC 1108; CDC 6600	
III	EVALUATE TRACKING	UNIVAC 1108; CDC 6600	
IV	STANDARDIZE DIGITAL TAPE (IR)	CDC 6600	

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Table VI. Machine Compatible Tape Format (Tape B)

Parity: EVEN
Density: 800 BPI
Char/Rec: 132 (1108); 100 (6600 S-tape)
FORTRAN I/O - BCD

NO.	NAME	DESCRIPTION	ENTRY	FORMAT	UNITS	COLUMNS
1		<u>Header Record</u>				
	NFILE	Number of images stored consecutively on this tape (maximum value = 250)	1	I5	NA	1-5
	IDAY	Date of tape generation (day)	2	I5	NA	6-10
	IMO	Date of tape generation (month)	3	I5	NA	11-15
	IYR	Date of tape generation (year)	4	I5	NA	16-20
	ITIT (I) I = 1, 4	Tape Title	5	4A6	NA	21-44
	NWDOT	Number of vows in image matrix = 100	6	I5	NA	45-49
	NREC	Number of columns in image matrix = 100	7	I5	NA	50-54
2		<u>Sentinel Record</u>				
	NSENT	Sentinel word to uniquely identify image record sequence, which follows this record = -511, 0-777	1	I10	NA	1-10
	IPIC	Counter for relative image number on tape	2	I10	NA	11-20
3-203		<u>Image Records</u>				
		Grey values for 100 x 100 word image, 200 records, 50 words each	1	50I2	Grey Number	1-100
		(Record types 2, 3 ... 203 are repeated for NFILE number of images)				
	EOF	End-of-file mark follows all images				

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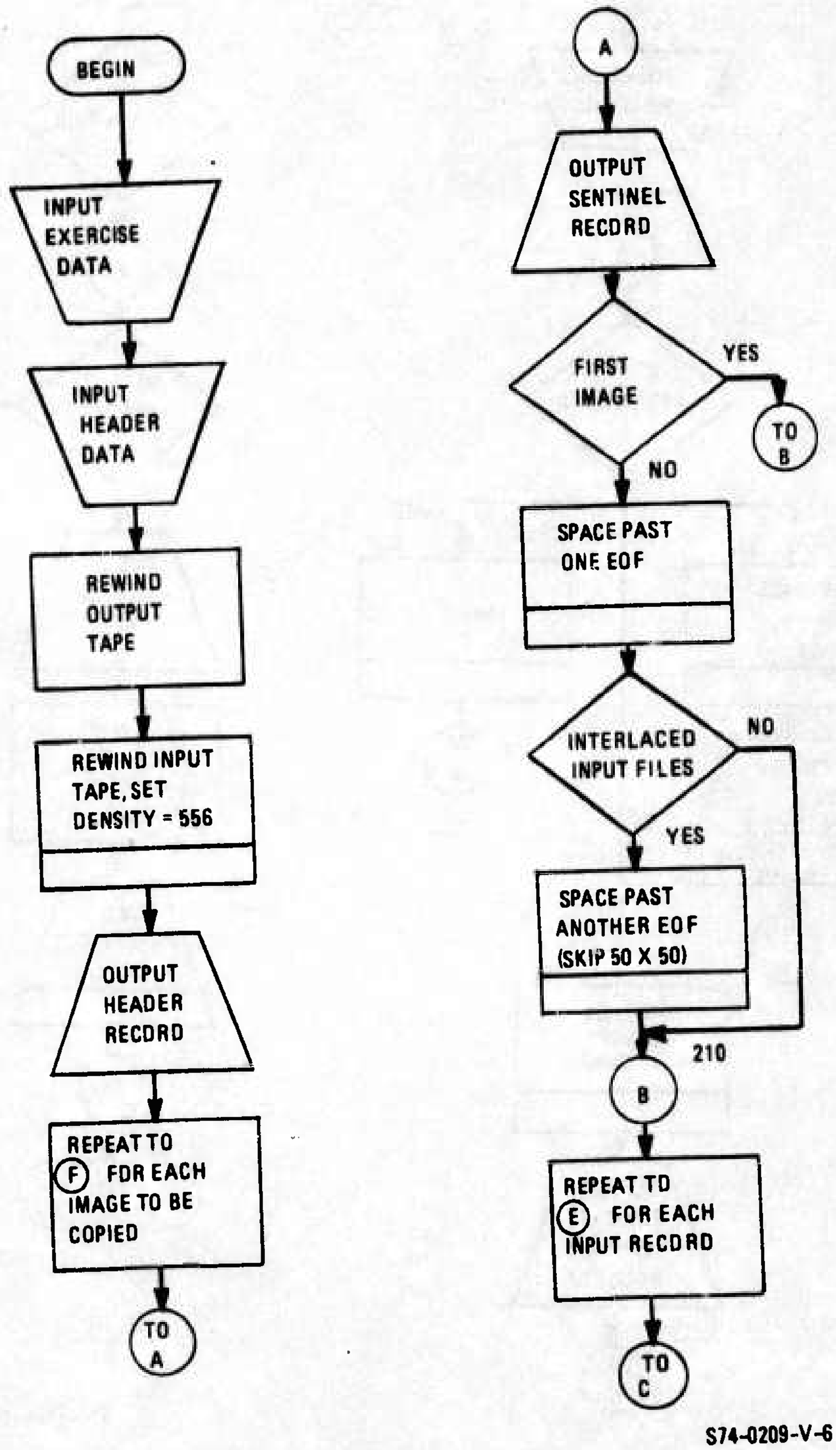


Figure 18. Tape Conversion Program Flow Chart

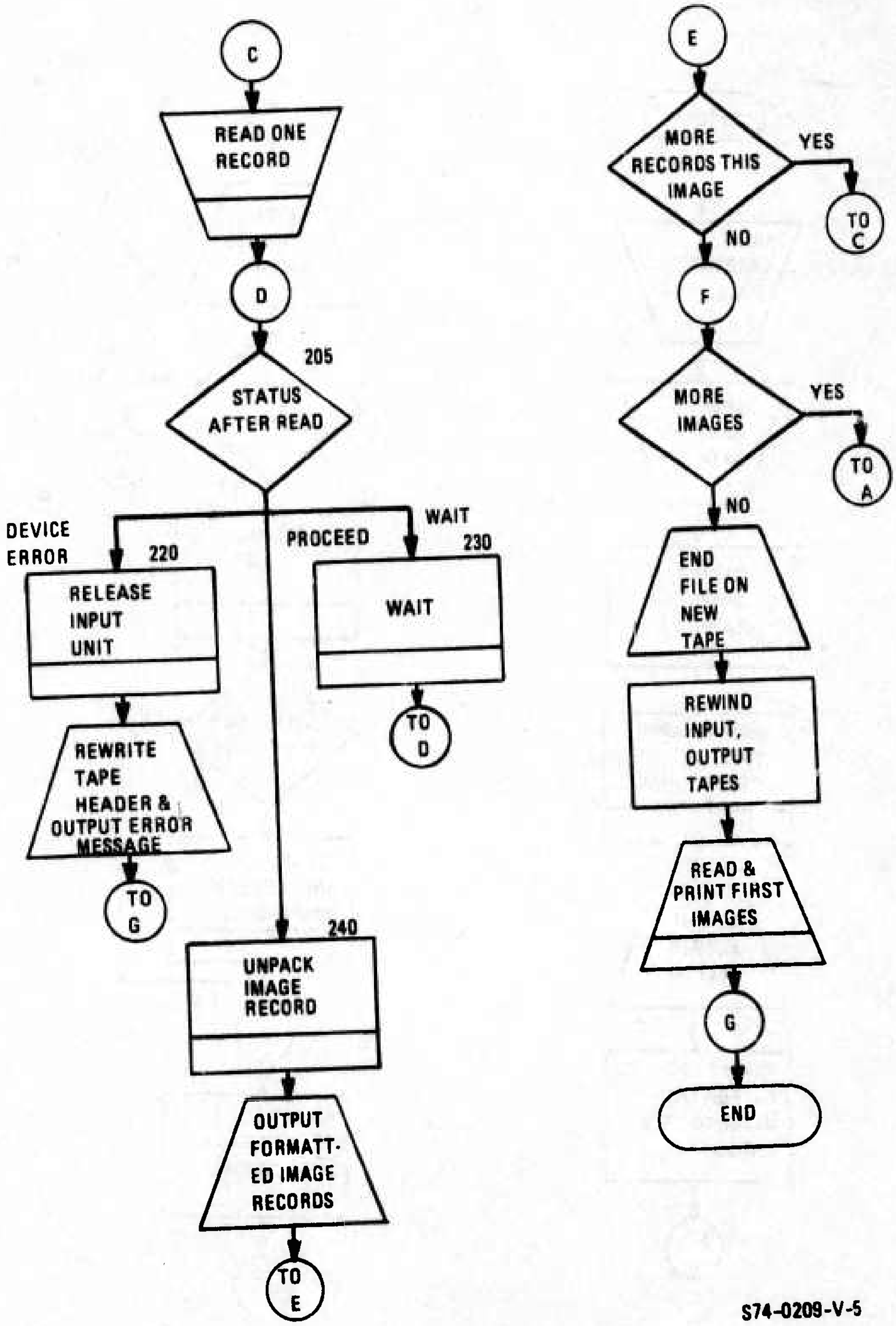


Figure 18. Tape Conversion Program Flow Chart (continued)

4.2.3 TV Imagery Data Runs

The production runs of the Computer Simulation Package were conducted with four selected samples of the TV imagery data, runs number 2 through 5 which are presented in Appendix IV. The input data runs are each composed of 126 frames of TV imagery, processed in sets of 21 frames. The data runs were taken from a TV video tape of a drone target aircraft being tracked by the AFWL Field Test Telescope on day number 299 of the test program. Run number one taken from this data was not used since it contained the same imagery as run number 4 but without a time code reference. Run number 2 also without a time code reference and run number 3 were processed early in the program using a monitor display which introduced a pattern of vertical bars of gradually increasing darkness from left to right across the imagery. This pattern was traced to interference in the monitor electronics and was eliminated from later runs by replacing the TV monitor. Data run number 2 shows the aircraft in level flight in front of a sky background. The drone fuselage appears dark and the sunlit wings light against the sky. The time of the start of the run was approximately hour 17 minute 46 on the time code clock.

Run number 3 selected from the same elliptical orbit of the drone target shows the aircraft against the sky background as it turns and reduces altitude at the left end of its orbit. This data set was chosen as an example of a rapidly changing target aspect with changes in the magnitude and polarity of the target

contrast as well. The first frame of this data run occurred at day 299, hour 17, minute 46, second 25.03 according to the time code reference.

Data runs numbers 4 and 5 were processed later in the program. At this time an array of light emitting diodes was constructed and mounted along the left edge of the monitor to display the time code. Run number 4, starting at day 299, hour 17, minute 46, second 31.37, shows the target in level flight at low altitude in front of a rapidly changing mountainside background. Run number 5, starting at day 299, hour 17, minute 46, second 44.67 shows the drone climbing across the mountain-sky horizon and changing aspect in the turn at the right end of its orbit.

4.3 IR IMAGE PROCESSING - COMPATIBLE TAPE GENERATION

Digital IR image tapes were prepared by the Computational Services Division at Kirtland Air Force Base, by direction of the Pointing and Tracking Branch (LRO) project office. The sequence of operations followed in processing these tapes is similar to that shown in figure 18. The source and tape format are different from the TV case. The program required to correct the data to a compatible format is also unique. The TV data was processed on UNIVAC machines, and the IR data was processed on a CDC 6600. The resulting compatible tape and printout are as similar as possible although obtained from different machines. No changes are required by the referencing program to process IR tapes.

Table VII gives the format of the IR digital input tape. The images recorded on the tape are of varying dimension, 40 x 130 or 40 x 260. The row dimension is fixed at 40. The fifth word of the header record preceeding each image record contains the column dimension of the subsequent image. The image values are stored as real numbers in volts.

A filler value is used for elements in the fixed size array for which no value was recorded. The value of the filler in each frame is the average of the second and third elements of the first column. Following the image data is a record containing the azimuth of each column. The image azimuth values have been configured so that the azimuth is generally increasing on each frame, creating a sawtooth scan. To accomplish this, the image and azimuth data on every other scan have been inverted. Actually, consecutive scans have increasing then decreasing azimuth.

The output tape produced by the conversion program (TAPRED) is consistent with the requirements of the referencing program, as described in table VI. This tape is processed on the 6600 as an S or stranger tape. The image size is limited by the referencing program which requires an array 100 x 100. Image elements are limited to 6 bits maximum value. A maximum of 250 images may be processed.

A flow chart of the processing sequence of the conversion program is given in figure 19. The program is composed of 9 FORTRAN routines.

Table VII. Digital IR Image Tape

NO.	NAME	DESCRIPTION	TYPE	SOURCE	UNITS	
1		Header Record				
	HEADER (1)	Time - hr	I		hr	
	HEADER (2)	time - min	I		min	
	HEADER (3)	Time - sec	I		sec	
	HEADER (4)	Time - msec	I		msec	
	HEADER (5)	Number of columns in image array (Number of rows = 40, fixed)	I		——	
	HEADER (6)	Time from start	I		msec	
	HEADER (7)	Minimum calibration value	I		mV	
	HEADER (8)	Maximum calibration value	I		mV	
2		Image Record				
	RLIMG (I,J) I = 1, 40 J = 1, HEADER (5)	Image values	R		v	
3		Azimuth Record				
	AZDAT (K),K=1, HEADER (5)	Azimuth corresponding to each column	R		rad	
/	EOF	End file. The above sequence is repeated for each image on tape. Final image is followed by a double end file. End of Information.				

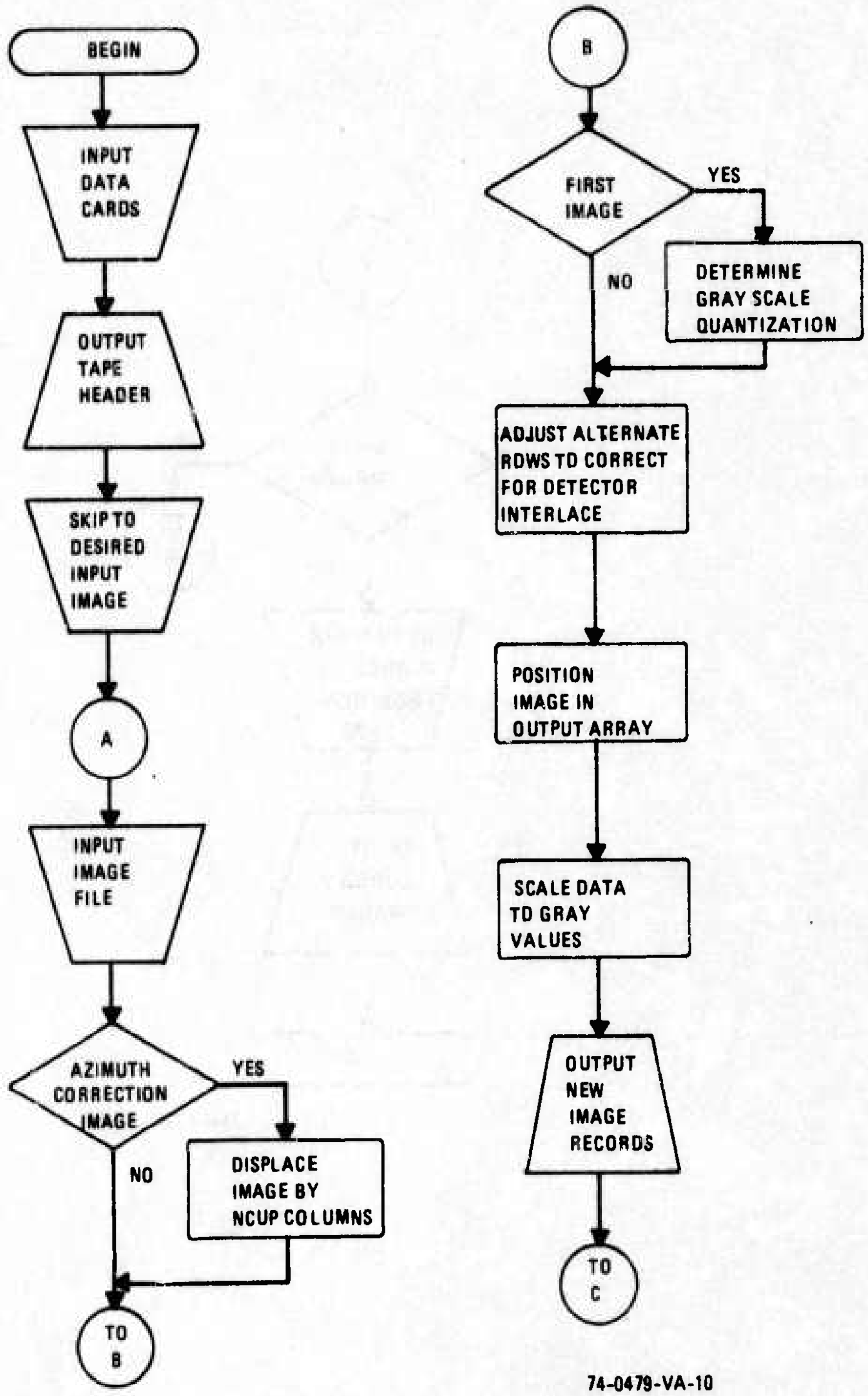


Figure 19. IR Conversion Program Flow Chart (TAPRED)

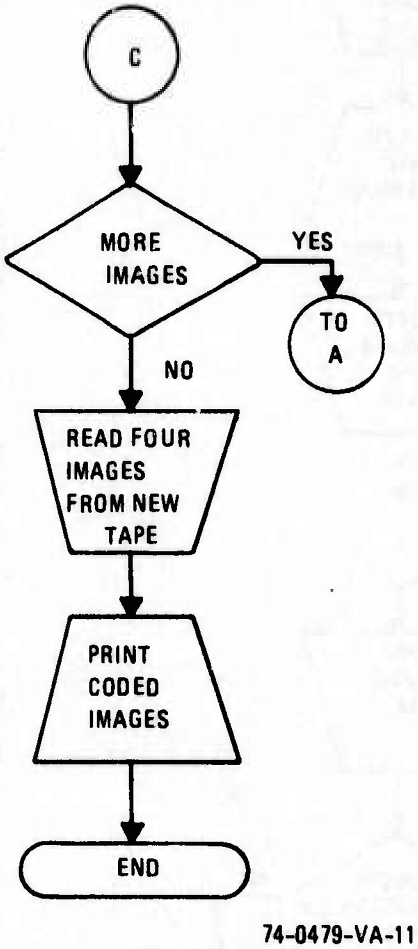


Figure 19. IR Conversion Program Flow Chart (TAPRED) (Continued)

Observed images show a constant azimuth position displacement of the target in the image field in consecutive scans. This bias may be caused by the inverted scan data, a recording problem, system noise, or a biased scan. The IR compatible tape generating program has an option to correct this bias.

Some processing is required to fit the IR image into a 100 by 100 array. For the small image (40 x 130), the first and last 5 columns are deleted. For the larger image (40 x 260), the first and last 10 columns are deleted. A 40 x 40 or 40 x 80 array is produced by averaging 3 consecutive columns. This resultant array is centered in the 100 x 100 array and the remaining rows and columns filled with a background value.

The IR detector array in the system has interlaced elements; therefore, at a given azimuth position, half of the detector elements, alternate ones, are lagging in azimuth. IR data are recorded before the system corrections are made, which results in distortion of the digital IR image. The conversion program adjusts alternate rows to correct for detector interface.

Image elements processed in the referencing program are assigned units in shades of gray. Since the IR data are recorded in volts, a conversion of the input data to gray scale is made before writing the compatible tape.

Two data cards are required for input to the conversion program. They contain control and printout options. The formats of these cards are given in table VIII.

Table VIII. Data Card Input To IR Conversion Program

NO.	NAME	DESCRIPTION	CARD	FORMAT	UNITS	COLUMNS
1	IFPULL	The number of the first row to be adjusted for detector separation. The adjustment is made to alternate rows by shifting the designated rows to the left, or in the transpose image, shifting up. This correction is made on each image processed.	2	I5	—	1-5
2	NPULL	Number of uncompressed elements to shift for detector separation - (NOTE: Output frames are compressed by a factor of 3)	2	I5	—	6-10
3	IFCUP	Indicator of which frames to adjust for azimuth scan correction = 1 = Odd numbered frames = 0 = Even numbered frames Adjustment is made to all rows in alternate images by shifting to the left, or in the transpose image, shifting up.	2	I5	—	11-15
4	NCUP	Number of uncompressed elements to shift for azimuth scan correction. (NOTE: Output frames are compressed by a factor of 3)	2	I5	—	16-20

Table VIII. Data Card Input To IR Conversion Program (Continued)

NO.	NAME	DESCRIPTION	CARD	FORMAT	UNITS	COLUMNS
1	NPIX	Number of IR frames to reformat on compatible tape (max = 250)	1	I5	—	1-5
2	NSKIP	Number of IR frames to be skipped before processing begins	1	I5	—	6-10
3	NOTAP	Output tape option $\leq$ 1 = Read IR tape, only produce printout $\geq$ 1 = Read IR tape, produce compatible output tape	1	I5	—	11-15
4	IPROUT	Printout level desired (Status printout is always produced) $\geq$ 1 = Quanitized image $\geq$ 2 = Unquanitized image (center only) $\geq$ 3 = IR input data	1	I5	—	16-20
5	IDAY	Day of tape generation (for output tape header)	1	I5	—	21-25
6	IMO	Month of tape generation (for output tape header)	1	I5	—	26-30
7	IYR	Year of tape generation (for output tape header)	1	I5	—	31-35
8	EXNAME-(I), I = 1, 4	Exercise title	1	4A6	—	36-59

SECTION V

TRACKER PERFORMANCE EVALUATION

This section details the results and data obtained with the CSP during evaluation of the digital correlation tracker and its options as compared with the edge and centroid trackers. Initial tests were performed on abbreviated sequences of 21 data frames. After the set of options was reduced, additional runs were performed on a variety of target/background and target variation scenarios. The tests were performed on both TV and IR imagery.

5.1 TRACKING EXPERIMENTS

Initial tracking experiments were run with the computer simulation package, CSP, to determine some of the basic tracker characteristics and the effects of parameter variations. The initial runs were abbreviated, having been run on a sequence of 21 successive frames; however, the data are relatively high contrast with high signal-to-noise ratio such that the effects are produced by geometric variations rather than noise.

The data set used is shown in the photograph of figure 20. The first picture appears in the upper right hand corner (top of first column reading from right to left). The next and subsequent pictures appear below it (seven total) with the eighth picture at the top of the middle column, etc. The data in the computer printouts which follow have the same vertical orientation but mirror image horizontal

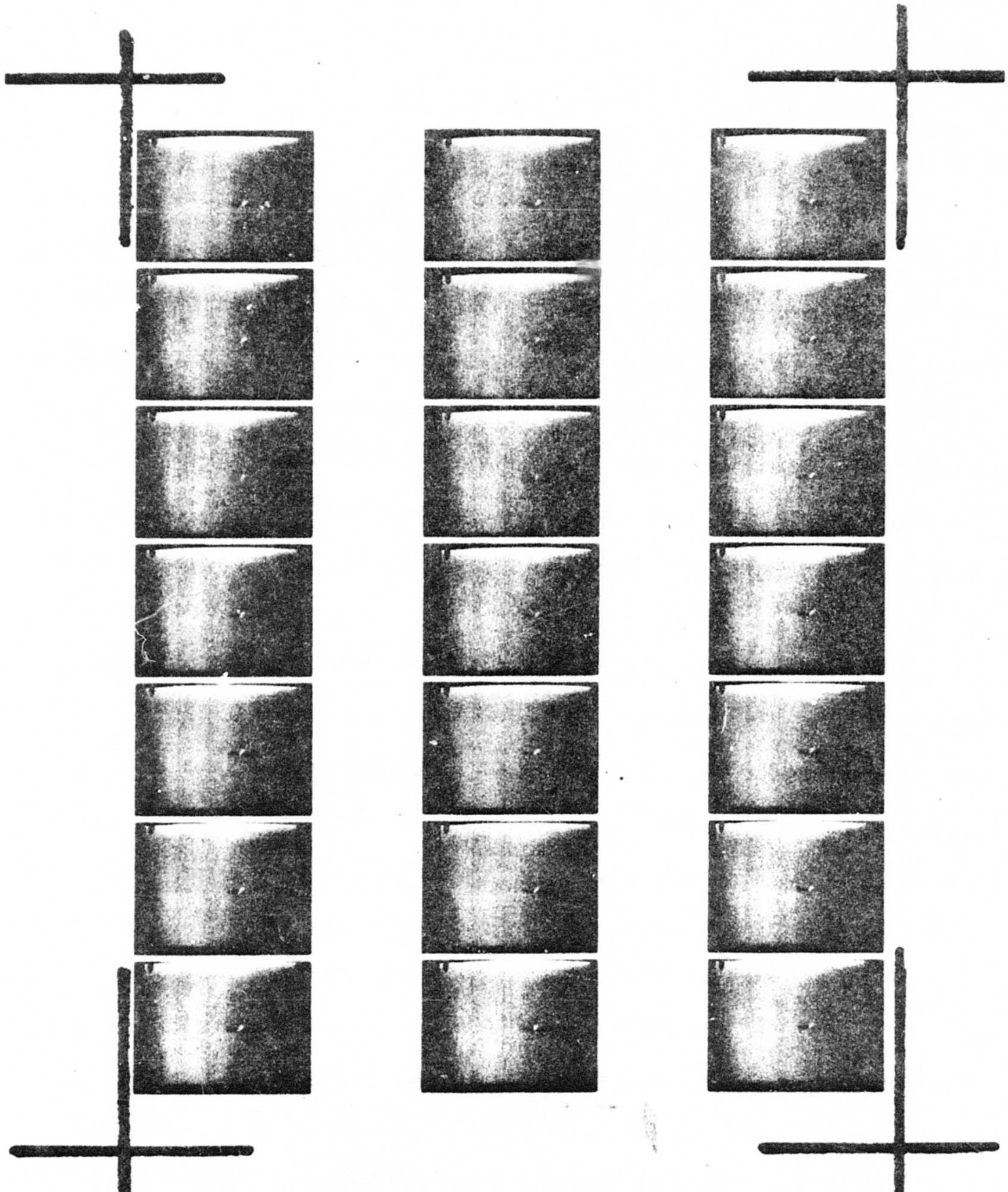


Figure 20. Target TV Imagery

orientation. This format occurs because of the scanning and recording method employed in the photoscan digitizer.

Two track points were used: (1) the nose of the aircraft, and 2) the section near the wing which is greatly foreshortened at the given aspect angle.

The accompanying figures summarize the data and show the pre-processed video in the 32 by 32 element windows. A rectangle has been drawn on these pictures to indicate the track window (16 by 16 elements). The run data are summarized in table IX.

The following general observations and conslusions are drawn from these data:

Observation:

In runs 39 through 43 (a track on the nose section), the vertical or y gain of the centroid and edge trackers is nearly unity while the horizontal gain averages around 0.4. This effect was explained in paragraph 3.2.2 on gain normalization. For most of these cases, the radial error would have been higher than indicated if gain normalization had not been used. In run 30, the centroid pattern is essentially within the window resulting in high x-and y-gains. The edge pattern however extends through both sides of the window leading to low x measure definition and consequently a low x-gain. Compensation for the low x-gain in the edge tracker results in low drift (bias errors are minimal) but high resultant noise error.

Table IX. Run Summary

RUN NUMBER	TRACKER	X GAIN	Y GAIN	RADIAL ERROR	DRIFT DISTANCE	COMMENTS
39	CENTROID	0.3740	0.9686	0.3505	0.2347	LIN/THRESH AT 40
	CORR.	1.0000	1.0000	0.2353	5.3466	UPDATE AT 1 FRAME
	EDGE	0.5423	0.9881	0.2137	0.1174	NO THIN
40	CENTROID	0.3897	0.9105	0.2639	0.4616	LIN/THRESH AT 32
	CORR.	1.0000	1.0000	0.2250	0.2431	NO UPDATE
	EDGE	0.4353	0.9986	0.4002	0.2863	
41	CENTROID	0.3803	0.9706	0.3752	0.2870	BINARY AT 40
	CORR.	1.0000	1.0000	0.2500	2.3865	UPDATE AT 4 FRAMES
	EDGE	0.4353	0.9986	0.4002	0.2863	
42	CENTROID	0.3632	0.9492	0.6750	1.3726	BINARY AT 40
	CORR.	1.0000	1.0000	0.2356	2.5563	UPDATE AT 4 FRAMES
	EDGE	0.3316	0.9453	0.8232	1.5943	
43	CENTROID	0.4381	0.9236	0.3260	0.6925	BINARY AT 40
	CORR.	1.0000	1.0000	0.2575	2.3302	UPDATE AT 4 FRAMES
	EDGE	0.3238	0.6858	1.3143	4.2817	
30	CENTROID	0.9516	0.8520	0.3322	0.9110	BINARY AT 40
	CORR.	1.0000	1.0000	0.0991	0.2509	UPDATE AT 4 FRAMES
	EDGE	0.0664	0.9628	4.4950	0.4001	
31	CENTROID	0.9598	0.8818	0.2822	0.7915	LIN/THRESH AT 40
	CORR.	1.0000	1.0000	0.0980	0.2086	NO UPDATE
	EDGE	0.2236	0.9664	1.4070	0.5812	NO THIN

Table IX. Run Summary (Continued)

TRACKING RUN NO. 39

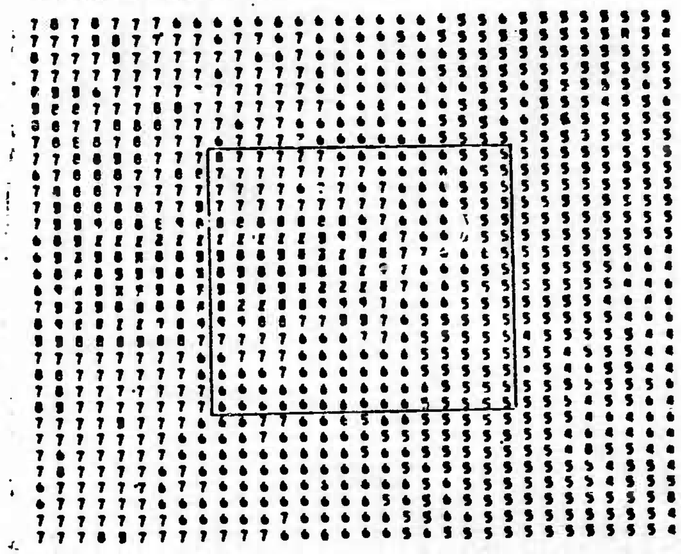
X DIMENSION = 16 Y DIMENSION = 16
X CENTER = 32 Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT PROC UNIT 1
-0 FRAMES SKIPPED. 21 FRAMES PROCESSED
FREQUENCY = 30.00
6 INPUT BITS USED
ICCLPS = 0 IOFP = 3
SCALCF = 4.00 SFACX = 5.00 SFACY = 5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT 1 FRAMES
LINEAR PROCESSING ABOVE THRESHOLD OF - 68 FOR CENTROID TRACKER

		RESOLUTION ELEMENTS			REGRESSION COEF	
CENTROID - X AXIS	MEAN	-7.031565E-02	RMS	3.946950E-01	BETA	-3.708296E-03
CENTROID - Y AXIS	MEAN	1.640452E-01	RMS	6.358167E-02	BETA	1.110633E-02
RADIAL ERROR(RMS)=	.3585					
DIG CORR - X AXIS	MEAN	2.190019E+00	RMS	2.290168E-01	BETA	2.669759E-01
DIG CORR - Y AXIS	MEAN	1.712936E-01	RMS	5.011632E-02	BETA	1.559217E-02
RADIAL ERROR(RMS)=	.2353					
EDGE - X AXIS	MEAN	1.027246E-01	RMS	1.909306E-01	BETA	2.702661E-03
EDGE - Y AXIS	MEAN	-1.376687E-01	RMS	8.751550E-02	BETA	4.492373E-03
RADIAL ERROR(RMS)=	.2137					

SAMPLE NO. 8 RUN NO. 39

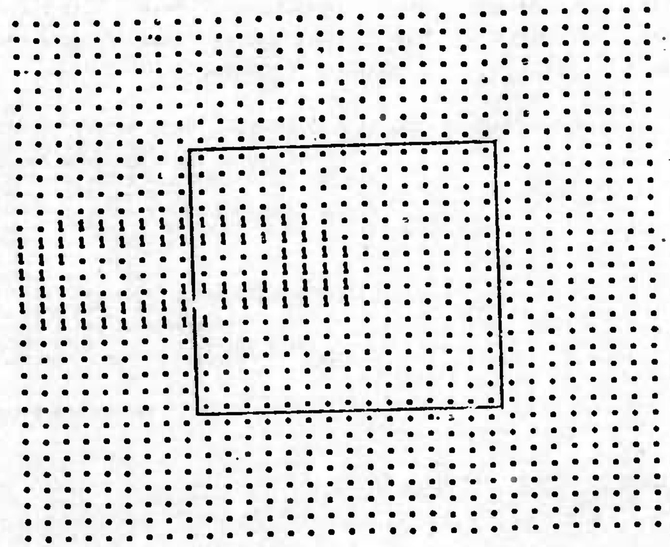
DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 6



EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1



CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 6

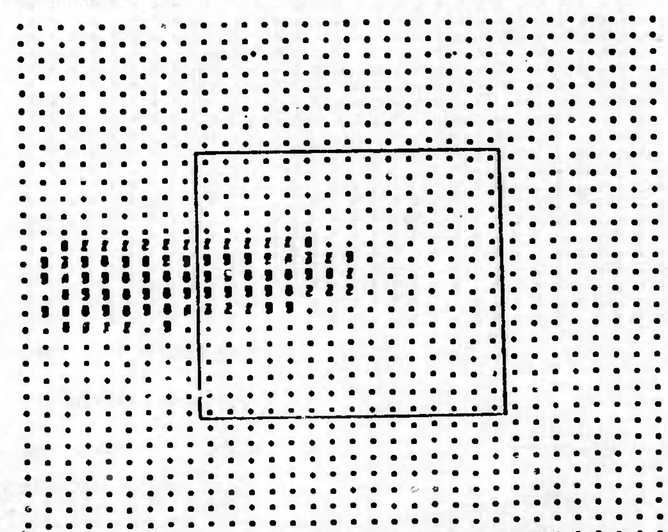


Table IX. Run Summary (Continued)

TRACKING RUN NO. 80

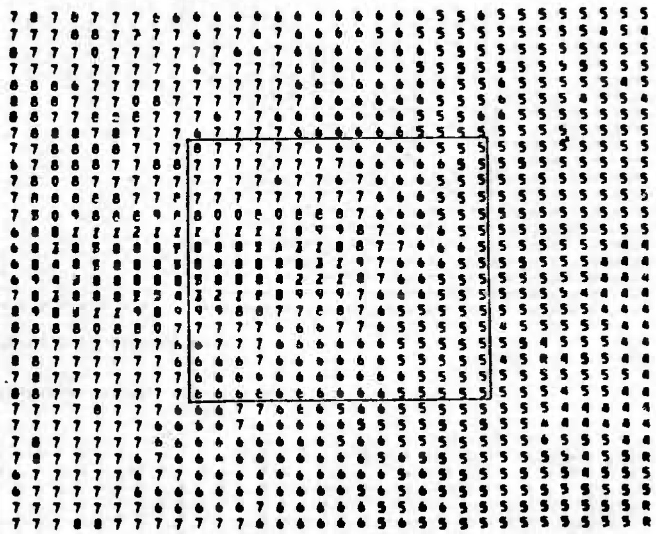
X DIMENSION = 16 Y DIMENSION = 18
X CENTER = 32 Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT 1
-0 FRAMES SKIPPED. 21 FRAMES PROCESSED
FREQUENCY = 30.00
6 INPUT BITS USED
ICOLRS = 0 IOFF = 0
SCALOF = 4.00 SPACX = 5.00 SPACY = 5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
THINNING USED FOR EDGE
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM O. ABS VALUES
UPDATE AT 99 FRAMES
LINEAR PROCESSING ABOVE THRESHOLD OF - 32 FOR CENTROID TRACKER

		RESOLUTION ELEMENTS				REGRESSION COEF
CENTROID - X AXIS	MEAN	-9.787678E-02	RMS	2.298238E-01	BETA	-1.187555E-02
CENTROID - Y AXIS	MEAN	1.777595E-01	RMS	1.287393E-01	BETA	1.978950E-02
RADIAL ERROR(RMS)= .2639						
DIG CORR - X AXIS	MEAN	-2.542319E-01	RMS	2.193121E-01	BETA	-1.548717E-02
DIG CORR - Y AXIS	MEAN	7.793058E-02	RMS	5.828773E-02	BETA	4.195595E-03
RADIAL ERROR(RMS)= .2250						
EDGE - X AXIS	MEAN	4.333788E-01	RMS	3.936337E-01	BETA	1.297498E-02
EDGE - Y AXIS	MEAN	-6.193825E-02	RMS	7.236468E-02	BETA	6.0538R8E-03
RADIAL ERROR(RMS)= .4882						

SAMPLE NO. 0 RUN NO. 80

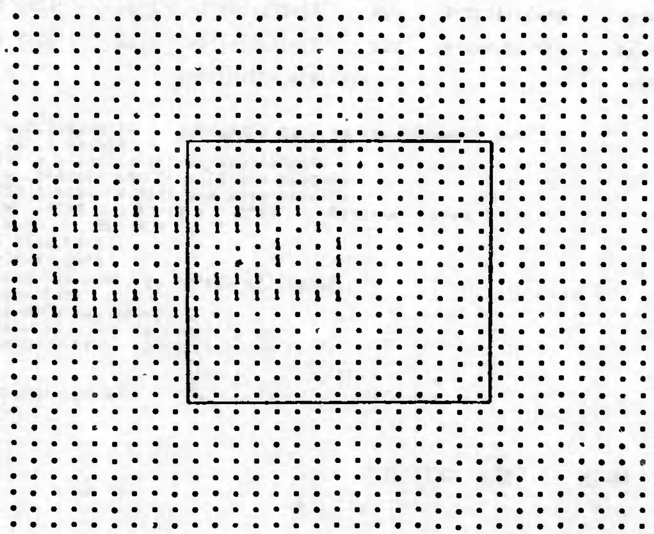
DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 8



EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1



CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 8

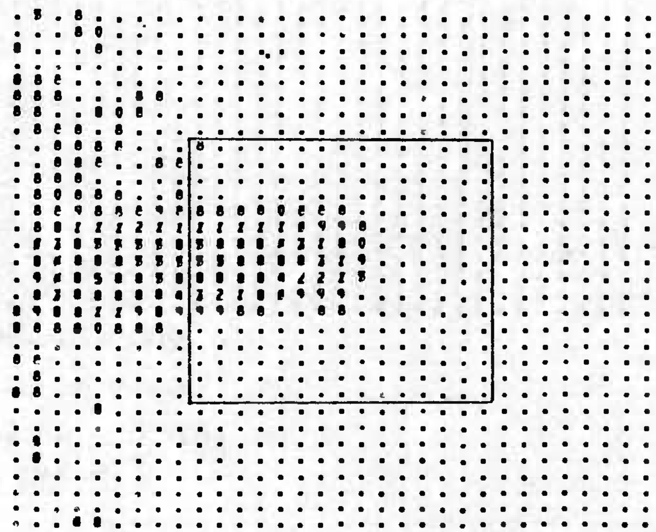


Table IX. Run Summary (Continued)

```
TRACKING RUN NO. 41

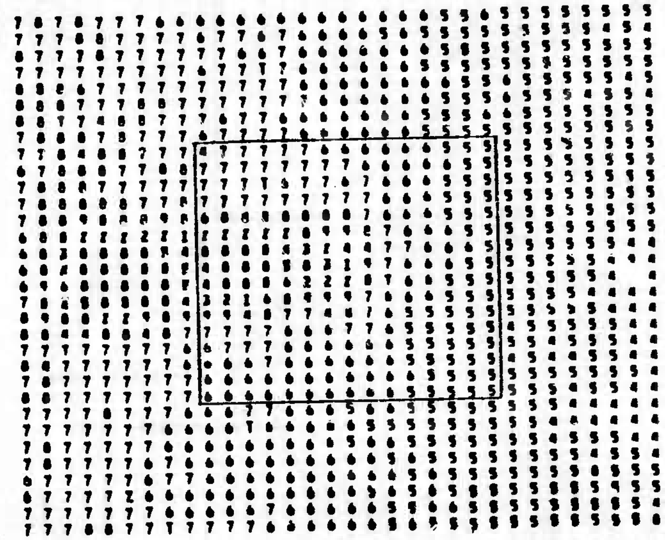
X DIMENSION = 16       Y DIMENSION = 16
X CENTER = 32          Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
 -0 FRAMES SKIPPED.  21 FRAMES PROCESSED
FREQUENCY =  30.00
6 INPUT BITS USED
ICOLPS = 0      IOFF = 0
SCALCF =   4.00      SPACX =   5.00      SPACY =   5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
THINNING USED FOR EDGE
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT  4 FRAMES
BINARY PATTERN USED FOR CENTROID TRACKER. THRESHOLD = 80
```

	RESOLUTION ELEMENTS				REGRESSION COEF	
CENTROID - X AXIS	MEAN	-1.199497E-01	RMS	3.601606E-01	BETA	-8.225218E-03
CENTROID - Y AXIS	MEAN	1.019848E-01	RMS	7.232954E-02	BETA	1.176142E-02
RADIAL ERROR(RMS)= .3752						
SIG CORR - X AXIS	MEAN	8.802789E-01	RMS	2.441275E-01	BETA	1.193239E-01
SIG CORR - Y AXIS	MEAN	4.306624E-02	RMS	8.384570E-02	BETA	-7.477653E-00
RADIAL ERROR(RMS)= .2580						
EDGE - X AXIS	MEAN	8.333790E-01	RMS	3.936337E-01	BETA	1.297490E-02
EDGE - Y AXIS	MEAN	-6.193825E-02	RMS	7.236468E-02	BETA	6.093000E-03
RADIAL ERROR(RMS)= .4882						

SAMPLE NO. 8   RUN NO. 41

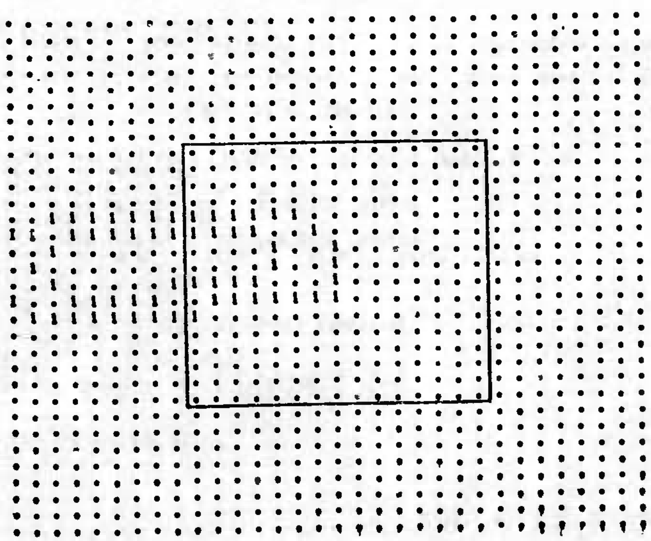
OCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 4



EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1



CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

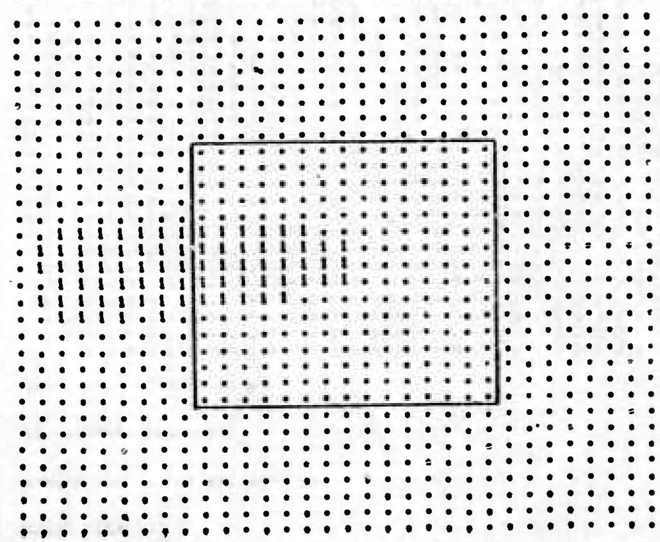


Table IX. Run Summary (Continued)

```
TRACKING RUN NO. 02

X DIMENSION = 16      Y DIMENSION = 16
X CENTER = 20         Y CENTER = 20
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
 -0 FRAMES SKIPPED,  21 FRAMES PROCESSED
FREQUENCY =  30.00
8 INPUT BITS USED
ICOLPS = 0      ICFF = 0
SCALOF =   4.00      SFACX =   5.00      SFACY =   5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
THINNING USED FOR EDGE
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT  8 FRAMES
BINARY PATTERN USED FOR CENTROID TRACKER, THRESHOLD = 40

                          RESOLUTION ELEMENTS                       REGRESSION COEF

CENTROID - X AXIS      MEAN    0.617655E-01    RMS   6.347976E-01   BETA    6.165761E-02

CENTROID - Y AXIS      MEAN   -8.202532E-02    RMS   2.295603E-01   BETA   -3.056653E-02
    RADIAL ERROR(RMS)=   .6753

DIG CORR - X AXIS      MEAN    9.150352E-01    RMS   2.300221E-01   BETA    1.270126E-01

DIG CORR - Y AXIS      MEAN    0.319523E-02    RMS   4.000445E-02   BETA   -2.153033E-04
    RADIAL ERROR(RMS)=   .2356

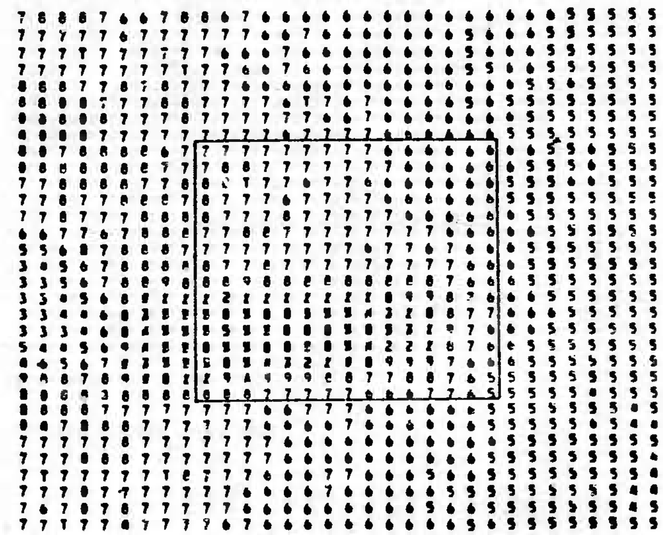
EDGE - X AXIS          MEAN    8.222640E-01    RMS   7.393828E-01   BETA    4.925159E-02

EDGE - Y AXIS          MEAN   -0.382129E-01    RMS   3.619196E-01   BETA   -6.268198E-02
    RADIAL ERROR(RMS)=   .8232
```

SAMPLE NO. 0   RUN NO. 02

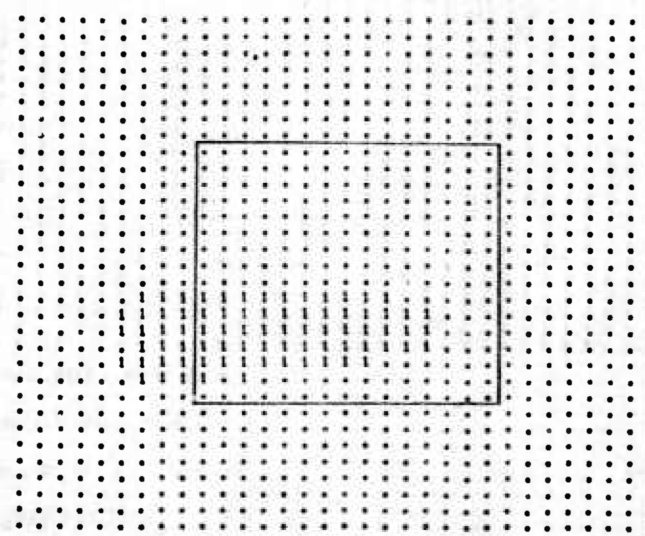
UC7 TRACKER INPUT DATA

INPUT DATA DIVIDED BY 4



CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1



EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

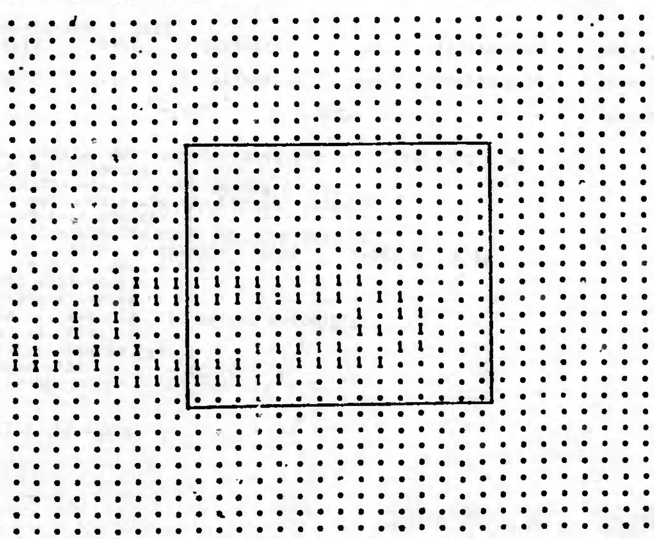


Table IX. Run Summary (Continued)

```
TRACKING RUN NO. 43

X DIMENSION = 16      Y DIMENSION = 16
X CENTER = 36         Y CENTER = 36
PRINTOUT EVERY 94 FRAMES
INPUT FROM UNIT  1
 =0 FRAMES SKIPPED,  21 FRAMES PROCESSED
FREQUENCY =  30.00
6 INPUT BITS USED
ICOLPS = 0      ICFF = 0
SCALOF =   4.00      SPACX =   5.00      SPACY =   5.05
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
THINNING USED FOR EDGE
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT  4 FRAMES
BINARY PATTERN USED FOR CENTROID TRACKER, THRESHOLD = 60

                         RESOLUTION ELEMENTS                         REGRESSION COEF

CENTROID - X AXIS      MEAN   3.171029E-01    RMS   8.830216E-01    BETA   1.561070E-02

CENTROID - Y AXIS      MEAN   2.632690E-01    RMS   1.403561E-01    BETA   3.089908E-02
    RADIAL ERROR(RMS)=   .3260

SIG CORR - X AXIS      MEAN   1.073711E+00    RMS   2.045494E-01    BETA   1.161303E-01

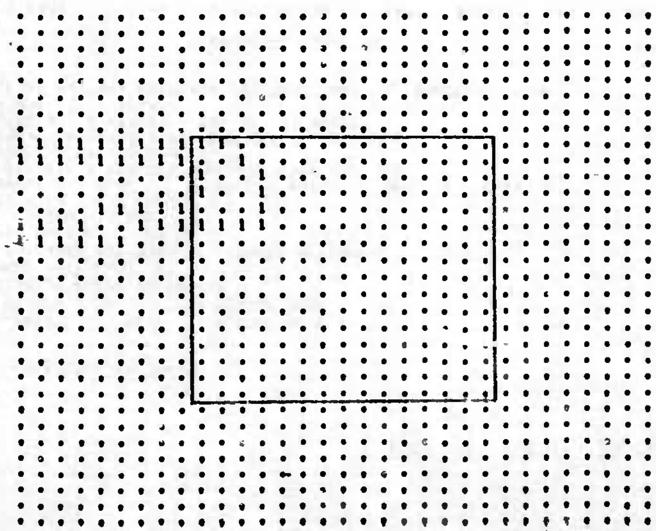
SIG CORR - Y AXIS      MEAN   4.050522E-02    RMS   8.077110E-02    BETA   9.360300E-03
    RADIAL ERROR(RMS)=   .2575

EDGE - X AXIS          MEAN   8.150953E+05    RMS   1.001493E+00    BETA   1.025292E-01

EDGE - Y AXIS          MEAN   5.090500E-01    RMS   5.326100E-01    BETA   1.078324E-01
    RADIAL ERROR(RMS)=  1.3143
```

EDGE TRACKER INPUT DATA

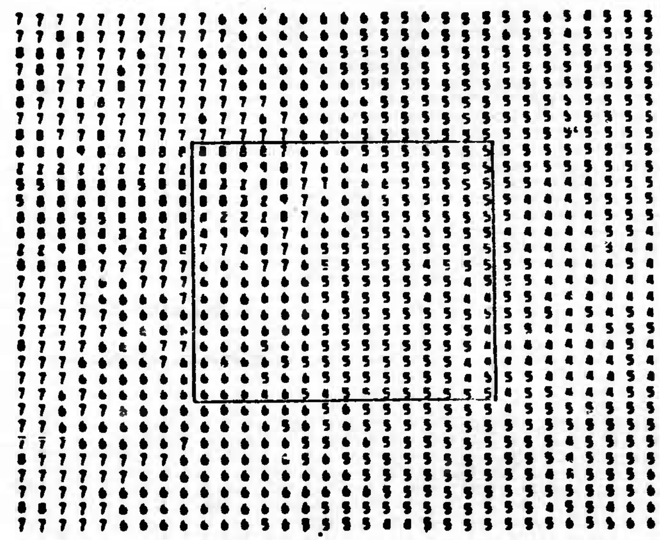
INPUT DATA DIVIDED BY 1



SAMPLE NO. 8   RUN NO. 43

SCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 4



CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

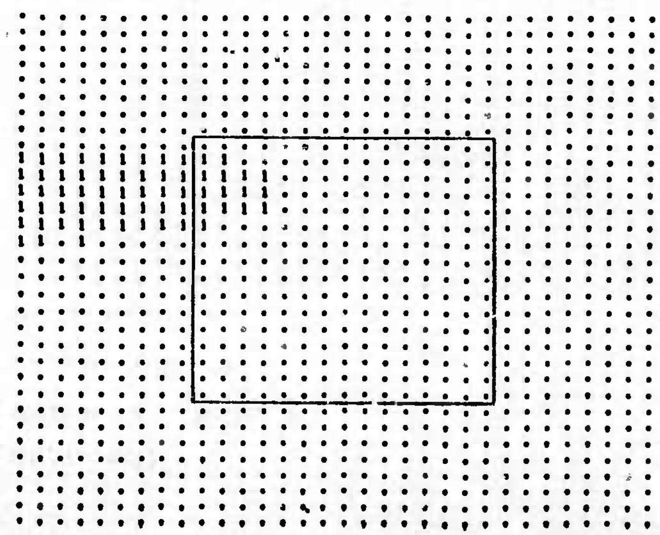


Table IX. Run Summary (Continued)

TRACKING RUN NO. 30

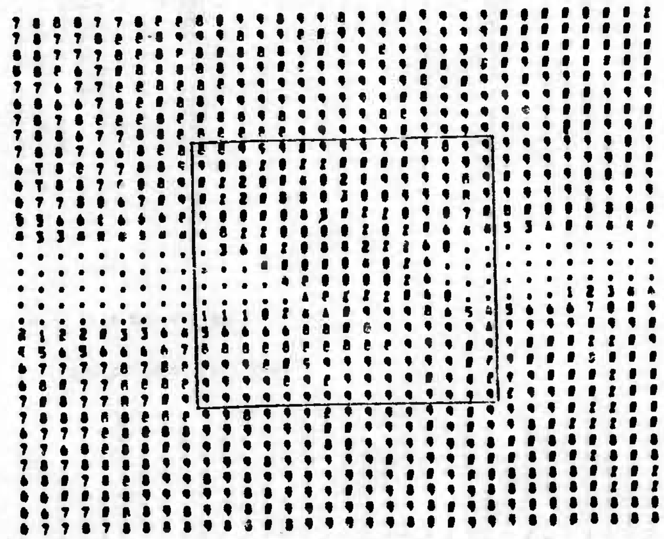
X DIMENSION = 16 Y DIMENSION = 16
X CENTER = 32 Y CENTER = 30
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT 1
0 FRAMES SKIPPED. 21 FRAMES PROCESSED
FREQUENCY = 30.00
6 INPUT BITS USED
ICOLPS = 0 ICPF = 0
SCALOP = 4.00 SPACX = 5.00 SPACY = 5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
THINNING USED FOR EDGE
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD = SUM OF ABS VALUES
UPDATE AT 8 FRAMES
BINARY PATTERN USED FOR CENTROID TRACKER, THRESHOLD = 80

	RESOLUTION ELEMENTS				REGRESSION COEF	
CENTROID - X AXIS	MEAN	-2.597030E-01	RMS	2.857611E-01	BETA	-1.373997E-00
CENTROID - Y AXIS	MEAN	1.063609E-01	RMS	2.234736E-01	BETA	8.340930E-02
RADIAL ERROR(RMS)=	.3322					
DIG CORR - X AXIS	MEAN	-1.308297E-01	RMS	6.688800E-02	BETA	-1.070031E-02
DIG CORR - Y AXIS	MEAN	1.189705E-01	RMS	7.588038E-02	BETA	-6.588665E-03
RADIAL ERROR(RMS)=	.0991					
EDGE - X AXIS	MEAN	-8.599072E+00	RMS	8.893510E+00	BETA	-1.792533E-02
EDGE - Y AXIS	MEAN	-9.080301E-02	RMS	1.188009E-01	BETA	-8.077977E-03
RADIAL ERROR(RMS)=	8.4950					

SAMPLE NO. 0 RUN NO. 30

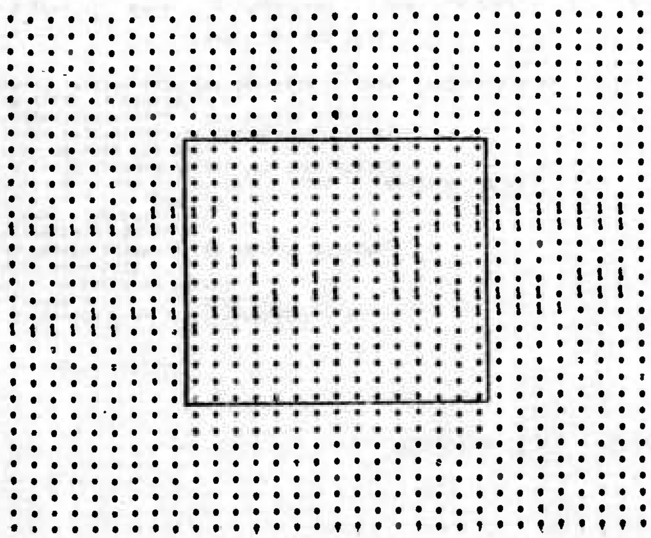
OCT TRACKER EARLY DATA

INPUT DATA DIVIDED BY 8



EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1



CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

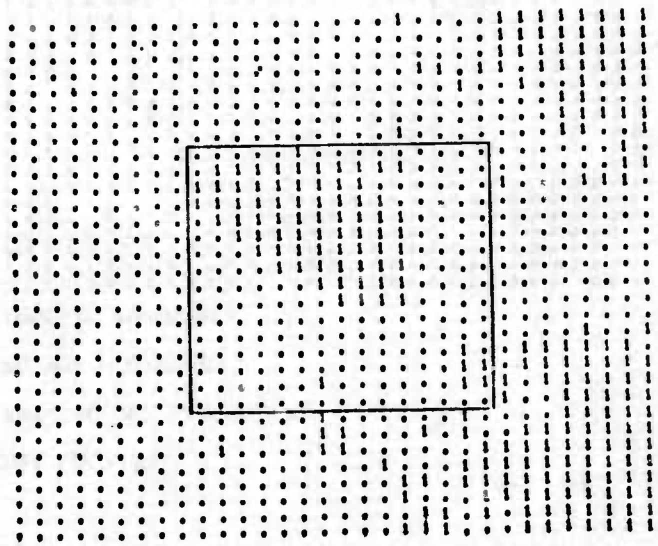


Table IX. Run Summary (Continued)

SAMPLE NO. 8   RUN NO. 31

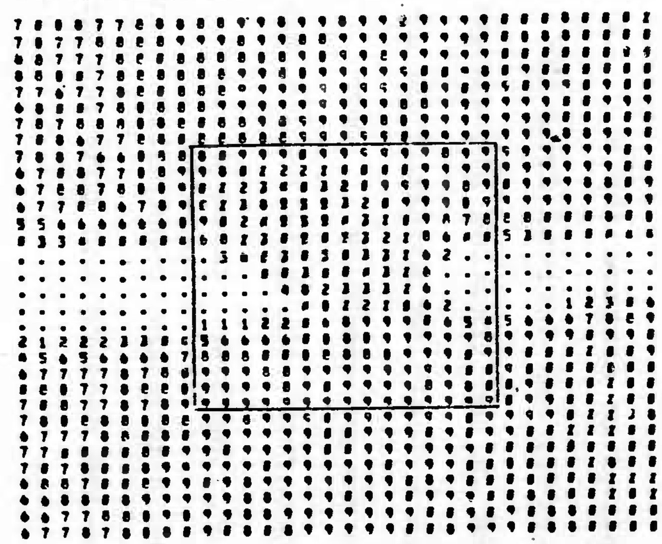
TRACKING RUN NO. 31

```
X DIMENSION = 16     Y DIMENSION = 16
X CENTER = 32        Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
 -0 FRAMES SKIPPED,  21 FRAMES PROCESSED
FREQUENCY =  30.00
6 INPUT BITS USED
ICOLRS = 0     ICFP = 0
SCALOF =   0.00      SPACX =   5.00      SPACY =   5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT 99 FRAMES
LINEAR PROCESSING ABOVE THRESHOLD OF - 80 FOR CENTROID TRACKER
```

		RESOLUTION ELEMENTS			REGRESSION COEF	
CENTROID - X AXIS	MEAN	-2.126900E-01	RMS	2.107892E-01	BETA	-1.031955E-02
CENTROID - Y AXIS	MEAN	1.023208E-01	RMS	1.077356E-01	BETA	3.020722E-02
RADIAL ERROR(RMS)=	.2002					
DIG CORR - X AXIS	MEAN	-1. 99150E-01	RMS	6.023217E-02	BETA	-7.154509E-03
DIG CORR - Y AXIS	MEAN	9.273785E-02	RMS	7.395008E-02	BETA	-7.500216E-03
RADIAL ERROR(RMS)=	.0900					
EDGE - X AXIS	MEAN	-1.912112E-01	RMS	1.003993E+00	BETA	2.750090E-02
EDGE - Y AXIS	MEAN	-1.906555E-01	RMS	9.212536E-02	BETA	-9.392067E-03
RADIAL ERROR(RMS)=	1.0070					

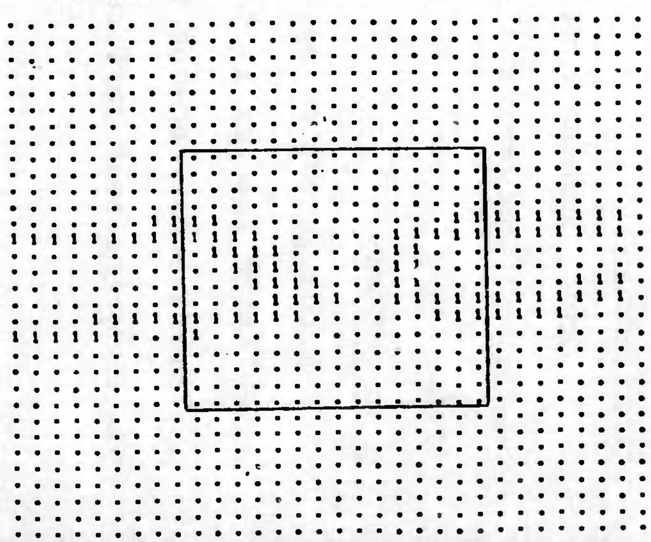
DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 8



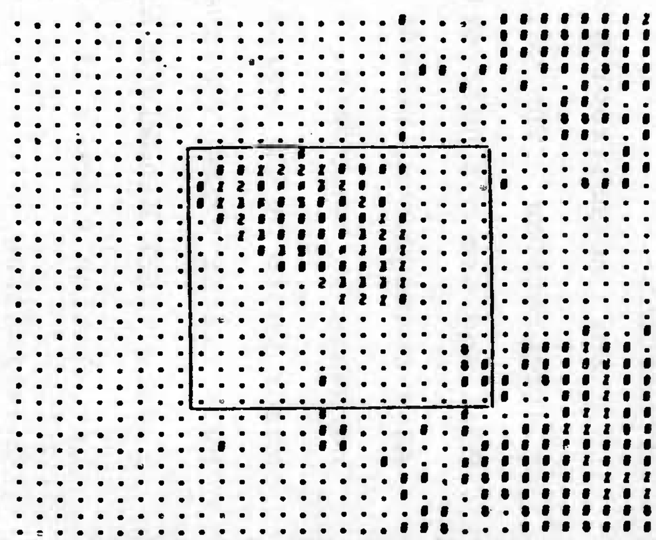
EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1



CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 4



Conclusion:

Gain normalization is required to compare the various configurations. The gains, however, are derived from the data and are not self-determined in the tracking algorithms. As a consequence, unless the gains could be adjusted in the hardware in accordance with the target geometry (or some means could be implemented to determine the gain on a frame by frame or frame average basis), the lower gains would reduce track bandwidth and dynamic tracking capability. The correlation tracker is a one-to-one measure and does not have this failing.

Observation:

Comparing run 39 with other runs indicates that for these cases thinning of the gradient pattern is detrimental.

Conclusion:

Since thinning requires extra operations its possible benefit is doubtful and future runs will not exercise this option.

Observation:

Although the noise (radial error) performance of the correlation tracker is consistent from run to run (39 to 43), the drift error depends on the update rate with no updates yielding the best performance.

Conclusion:

The update rate should be tied to frame-to-frame correlation and some means will have to be found to implement the appropriate measure and logic.

Observation:

Comparing runs 41, 42, and 43, it is noted that while the correlation tracker yields consistent results, the edge and centroid tracker results vary greatly. All conditions remained the same for these runs except the initial track point which was offset 4 units in each axis from a nominal position (that is: run 41, x = 32 and y = 32; run 42, x = 28 and y = 28; run 43, x = 36 and y = 36).

Conclusion:

The performance of the edge and centroid trackers depends strongly on the initial choice of track point and/or target geometry while the correlation tracker is independent of this choice (over a small region).

Observation:

Comparing runs 39, 40, and 41, it is noted that better performance in the centroid tracker is obtained with linear-above-threshold rather than with binary preprocessing. At a threshold level of 40 (out of 63), the performance is about the same, while setting a threshold level of 32 yields significantly better performance.

Conclusion:

Performance of the centroid tracker is threshold level dependent (another manifestation of geometric dependence induced by threshold level setting). A threshold must be used since the background weighting would produce very low x and y gains. Further, not only must the appropriate threshold be found but also the proper contrast sign must be determined. This latter effect could produce severe problems under contrast sign inversions produced by changing backgrounds. The correlation tracker does not have this failing because it can operate with linear data. Neither does the edge tracker since it operates on the magnitudes of the contrast changes.

5.2 EVALUATION OF REFERENCE PROGRAM ON FIXED TARGET IR DATA

An experiment was performed to test the referencing program against a stationary target viewed by the FTT sensor. Data were provided by AFWL in the form of digitized tape records. The tapes were preprocessed to form input data suitable for application in the referencing program (details are given in Section IV). The preprocessing quantizes the data into 64 grey levels, provides for alternate channel destaggering,and frame to frame position shifts. Data in the azimuth or x-direction are also digitally integrated to approximate equivalent x- and y-channel resolutions. The target, a square, was measured in both wide- and narrow-angle fields of view. Referencing program data are shown on pages 346 and 376. The data were analyzed to obtain the results summarized in Table X.

Table X. Reference Program Against Stationary Target

FOV	X-CHANNEL			Y-CHANNEL		SNR_e	NUMBER of SAMPLES
	Stagger	Mean	rms	Mean	rms		
Narrow	0.1135	-0.3241	0.2571	0.0854	0.0699	6.921	98
Wide	2.5200	-0.1145	0.5903	0.2493	0.3499	3.163	88

Offset data were obtained from a mean of the average jump between alternate data frames; the jump was subtracted to compute the overall statistics for a given run. As indicated, the offset bias for the narrow-angle FOV was almost perfectly preset. Introduction of the appropriate offset minimizes the required search range of the referencing program; the offset does not affect the ability of the reference program to position the target.

The data, as analyzed, include the effects of track point drift. When drift is accounted for, the apparent rms errors are smaller than indicated values. As noted, the x-channel errors are inversely proportional to the effective signal-to-noise ratio. No effective processing is performed on Y-channel data and the resultant noise is smaller; the X channel data reflect noise that occurs in the preprocessing to form integrated and destaggered patterns.

In both cases, the combined effects of noise and drift result in track point motion of less than an element dimension rms.

5.3 CSP DATA

The computer printouts contained in Appendix V are reference and track programs on the targets indicated in table XI. The data in these figures are presented in the following forms.

For the reference program, a table of coordinate error values is presented which indicates the target track point relative to its initial value in the first data frame. The interpretation of these data varies as a function of the type of target being referenced: for the IR data with a stationary target, the data serve to evaluate the reference program (as indicated in the previous section); for the IR data with a moving target, the data indicate actual FTT tracker performance versus the referencing

Table XI

Target Run Summary

Run Number	Target Description	Sensor
80	A/C Level Flight; Sky Background - Track on Wing	TV
82	A/C Aspect Changing in Turn; Sky Background; Track on nose	TV
84	A/C Level Flight; Mountain Background; Track on Tail	TV
86	A/C Climbing and Turning; Crossing Horizon; Track on Nose	TV
88	Stationary Target NFOV	IR
90	Stationary Target WFOV	IR
92	A/C Target; Track on nose; NFOV	IR
94	A/C Target; Track on nose; WFOV	IR

program performance in interpretation of the same data; for TV data, these data include both FTT tracker errors and the gross errors due to initial target identification pinhole positions applied manually. Other reference program data included a table of effective signal-to-noise ratios computed over groups of 10 data frames. It is noted that for the TV data, the values can be scaled to actual values by multiplication by 0.005 times the vertical field of view dimension; the IR data values can be obtained by sizing the rectangle shown in the stationary target data.

The track program data are presented in the following format: The initial sets are 32-by-32-element windows of the last frame in the sequence. These include the input data, video gradient data, edge tracker input data, correlation tracker input data, and centroid tracker input data. The next printout indicates the 16 by 16 correlation reference matrix (or submatrix of data from which the reference vectors are derived) and error and input value data.

The next printout indicates the run conditions and a table of derived tracker channel gains. Subsequent printouts indicate listing of raw and track loop filtered errors, the statistical data (rms radial errors and drift from a regression analysis) derived from the input data, and finally the power spectral density calculations and plots for the data.

Tracking jitter (rms radial error) and track point drift are summarized in table XII.

As a general note, the correlation tracker configuration employed in these CSP runs represents that upon which the preliminary design given in Section VI was based. The configuration uses 5-bit input data, the sum of absolute values metric, and a single iteration exhaustive search of the input data.

Table XII

Track Point Jitter and Drift

Run Number	Jitter Resolution Elements RMS			Drift Resolution Elements		
	Corr.	Centroid	Edge	Corr.	Centroid	Edge
80	0.1052	0.464	1.9554	1.0992	0.1425	1.1998
82	0.4275	0.6283	0.5794	2.6858	4.4465	3.7750
84	0.5248	0.7894	2.1277	1.5570	2.6720	8.1201
86	1.2390	3.3139	2.6211	3.3134	7.117	10.8888
88	0.0884	0.1053	0.2755	0.4539	0.4295	0.5178
90	0.3021	0.2910	0.5259	0.9743	0.8748	0.8322
92	0.4863	0.6276	0.900	2.2543	3.3800	15.5169
94	0.2660	0.4273	1.3331	1.3408	0.7466	1.4386

SECTION VI

PRELIMINARY DIGITAL CORRELATION TRACKER DESIGN

6.1 INTRODUCTION

During the analytical evaluation of the digital correlation tracker three separate approaches to the correlation tracking implementation were considered. Early in the Phase I analysis a gradient search for location of the correlation function maximum and a measurement of the correlation function centroid were considered as techniques for deriving tracking error signals. Both techniques were discussed in the "Proposal for a Digital Correlation Tracker" dated 31 May 1973. The latter of these two techniques was quickly rejected because of the number and complexity of the calculations required which made it impractical to implement for real time, high data rate operation. Investigation of the gradient and other search techniques continued through the first three months of the program as the first principal approach to the tracker implementation. The search techniques also were abandoned when it was found that the correlation function was irregular and frequently local false maxima were found producing erroneous tracking error signals.

Since the search techniques had proven unsatisfactory, various methods of reducing the number of calculations required to conduct an exhaustive examination of the track window for the correlation function maximum were considered. Two particular procedures were

selected. The first was a reduction in the number of elements in the picture vector through the summation of blocks of 4 contiguous picture elements to create new data elements in a lower resolution picture. A 32- by 32-element picture would be converted into a 16- by 16-element and then an 8- by 8-element picture array. The location of the correlation function maximum would then be found first in the low-resolution 8- by 8-element array which locates the region to be examined in the 16- by 16-element array. The location of the correlation maximum in this array in turn isolates the area to be examined in the high-resolution 32- by 32-element array where the final location of the maximum is found and tracking error signals are derived.

The second procedure for reduction of the number of calculations involved the derivation of lower dimensional arrays representative of the picture array. The location of the position of the correlation function maximum between these arrays derived from the reference picture and the new imagery would then be found. Implementation of this procedure is accomplished, for example, by taking the 256 picture elements which comprise a 16- by 16-element picture array and adding the elements in each row to form a linear array, or marginal vector, of 16 values representing the rows of the picture. Similarly, the elements in each column are processed to form a second linear array. The x and y coordinates of the maximum of the correlation functions between the marginal vectors for the reference picture and those for the scene within the track window are then located. The

computation thus involves correlation between four 16-element linear arrays for each possible target location instead of the original two 256-element arrays.

At the start of the preliminary design effort, work was centered on the development of a configuration incorporating both of these procedures to minimize the number of calculations. The algorithm to be implemented in the design was as described in section II of this report taken from R&D Status Report No. 5 dated 30 March 1974. This second approach, because of the variety in the types of calculations required, led to a design configuration incorporating the features of a minicomputer. The resultant design concept, described in R&D Status Report No. 6 dated 30 April 1974, was finally rejected due to the high degree of complexity and cost of the minicomputer.

A compromise approach was then taken which included only the second of the above procedures involving the generation of tracking error signals from the marginal vectors. Implementation of this algorithm described in section V of this report was the final objective of the preliminary design effort. A description of the design configuration selected to implement this algorithm in the digital correlation tracker hardware is presented in the following paragraphs. This third approach possessed the advantages of lesser circuit complexity and cost while yielding improved tracking accuracy as compared to the second approach. On the other hand, the number of calculations required was greater, thus requiring higher speed logic elements.

The correlation tracker design has been divided into three areas: the Interface Electronics, the Video Processor, and the Correlation Processor. Each is described separately in the next three paragraphs. The interface electronics will interface with the two TV cameras and the IR sensor. Video gray levels from the TV cameras are converted into digital words on a cellular basis. IR sensor data are rearranged into a TV raster type format and converted to a digital form. Video sync separators are provided for both horizontal and vertical sync. Azimuth and elevation position stick levels from the operator controls are rate limited and excursion limited within the sensor field of view. Error signal outputs to the tracking servo system are developed with respect to these initial stick positions.

The video processor will operate on the digital words from the interface electronics. The primary function of this portion of the tracker will be to store the picture data within a 32- by 32-element array representing the tracking window. The data are stored in a format which will permit access as required for processing by the correlation processor. Azimuth and elevation time modulators will position the tracking window within the sensor field of view by selecting the data elements from the total picture array as a function of digital numbers supplied from the correlation processor. Picture data from any one of the three sensors are stored in a fixed 32- by 32-matrix array of memory cells. Variation in the size of the tracking window within the field of view is effected in fixed steps. To increase the range

window from a 32 by 32 array of picture elements to a 64 by 64 array, each group of four contiguous picture elements within the picture matrix is summed before storage in the 32 by 32 array of memory cells. The summing procedure can be performed twice successively to increase the range window size to effectively a 128 by 128 picture element array. In each step, a corresponding loss of resolution and tracking accuracy is incurred.

The primary function of the correlation processor, the third portion of the digital correlation tracker, is to locate the position of the 16- by 16-element matrix of stored picture data which yields a maximum correlation with the reference picture. The reference picture for this procedure is a 16- by 16-element array of picture data processed and stored from prior frames which defines the target position. This is compared with each 16- by 16-element area of data within the 32- by 32-element tracking window in the search for the correlation function maximum. The coordinates of the array which yields the maximum correlation are then processed to derive tracking servo error voltages in azimuth and elevation. The correlation processor also derives updated reference pictures as required and detects loss of tracking as a drop in the maximum correlation function derivable from data within the tracking window.

6.2 INTERFACE ELECTRONICS

The correlation tracker is designed to accommodate imagery signal inputs from any one of three sources: a 525-line TV, a 945-line TV, and an IR sensor (thermal imager). Composite video

is delivered from the two TV's and 4 channels of video, and sync signals are available from the IR sensor. Separate buffer amplifiers and clamping circuits are supplied from each input.

The required sync signals for tracker operation with the TVs are removed from the composite video in the sync strippers. This process yields odd/even line, frame begin, horizontal blanking, vertical blanking, and frame end signals. The horizontal blanking is used for resetting the blanking level of the composite video to 0 Vdc at the input to the analog-to-digital (A/D) converter.

The IR format is very different from that presented by the TV and this must be rearranged to be compatible with the horizontal scan lines of the TV. Four signals are supplied from the IR: composite video with retrace, vertical position, horizontal position, and system clock. The composite video will yield an equivalent horizontal blanking signal to reset the blanking level. The vertical position signal will yield up/down/top or bottom information. The horizontal position signal will yield left/right/left edge or right edge information.

The sensor outputs with zero blanking level restored will then be switched as required into the A/D converter. One A/D converter is used to accommodate the three sources. The converter is intended to be 5 bit, operates at 32 MHz, and is of the resistor ladder-comparator type.

Figure 21 is a photograph of a 5-bit unit capable of operating at 300 MHz. The 5-bit system has been in use for several years.

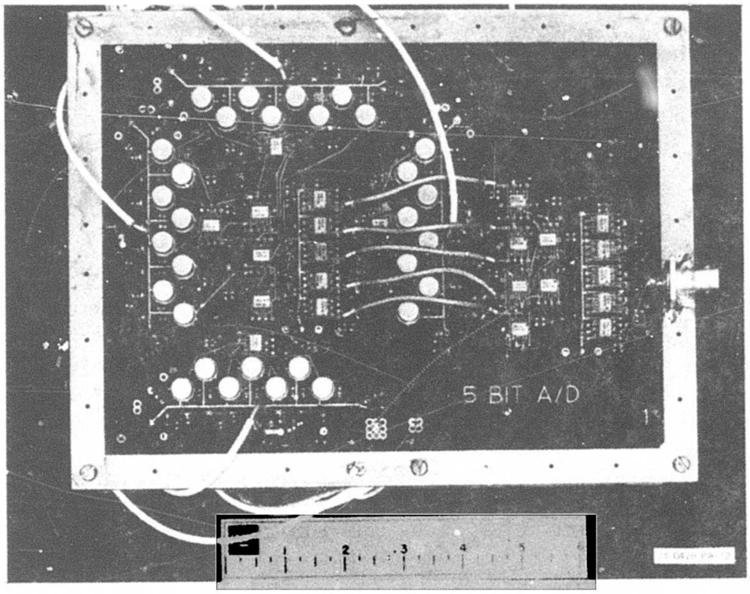


Figure 21. 5-Bit A/D Converter

Multiple drive points will be necessary in the converter as will a circular type layout to equalize signal propagation times. Figure 22 shows the proposed layout.

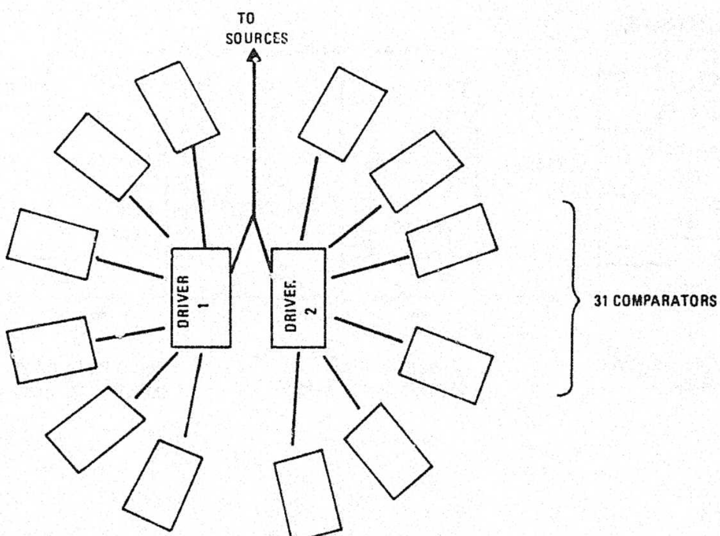


Figure 22. 5-Bit A/D Layout

At this time it is envisioned that the comparators will be operated on a continuous basis with the TV's. The IR may require a sample and hold technique and this can be easily mechanized by proper gating of the comparators. Figure 23 shows the proposed gating arrangement for the converter.

After the video data from the TVs is converted it is stored in RAMs until the end of the active time when processing begins. The data from the IR, however, are delivered to the tracker in a multiplexed staggered form and must be processed by indexing and axis inversion before they may be stored.

A cursor control stick is provided for each tracker which will work in conjunction with a cell size switch. The cell size switch selects 1, 2, or 4 TV size lines to represent the edge

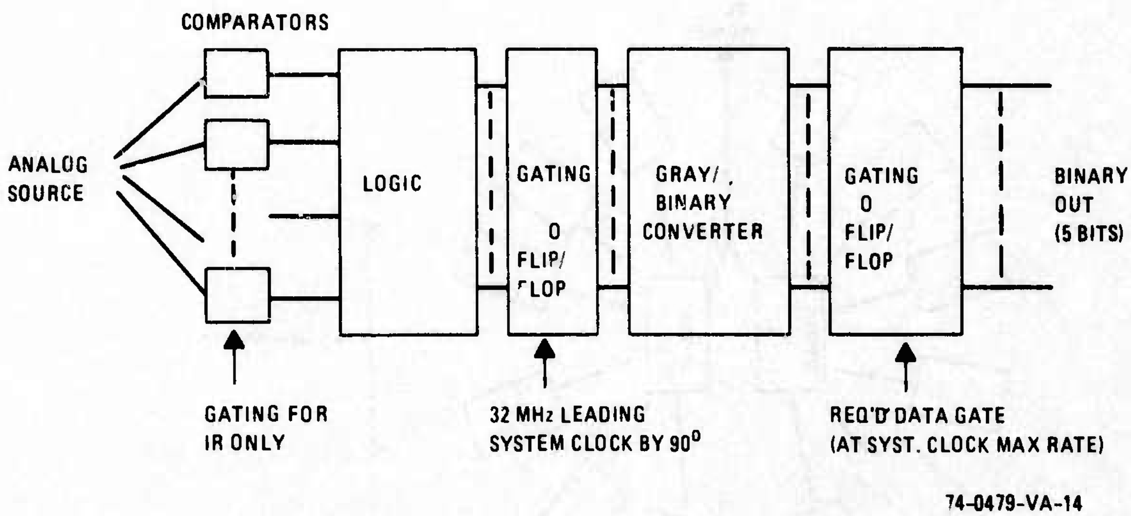


Figure 23. A/D Gating

dimension of a square data cell. The cursors will form a 16-cell by 16-cell reference block with the different trackers being denoted by either horizontal or vertical stripes delineating the edge of the block. The cursors form the reference matrix of a 32-cell by 32-cell active area. The maximum cursor rate will be limited to about 4 cells per frame time by an analog circuit to ensure that the input from the control stick does not change too rapidly to interfere with proper tracker action. The active region of each tracker is also limited to the active screen area of the monitor to ensure that the tracker cannot look at blanked video.

The horizontal and vertical address of the sensor electron beam is also generated and used in cursor production and in other sections of the tracker.

Figure 24 shows a block diagram representation of these circuit functions.

6.3 VIDEO PROCESSOR

6.3.1 Introduction

The principal function of the video processor is to take the sensor video information from either of the television cameras or the infrared sensor and create basic picture elements (pixels) in the format that is useful to the correlation tracker. Basic to this task is the generation of a video window from coordinate information received from the correlation tracker and creation of a strobe pulse for the video analog to digital converter. Also needed are the creation of pixels from the digitized video in

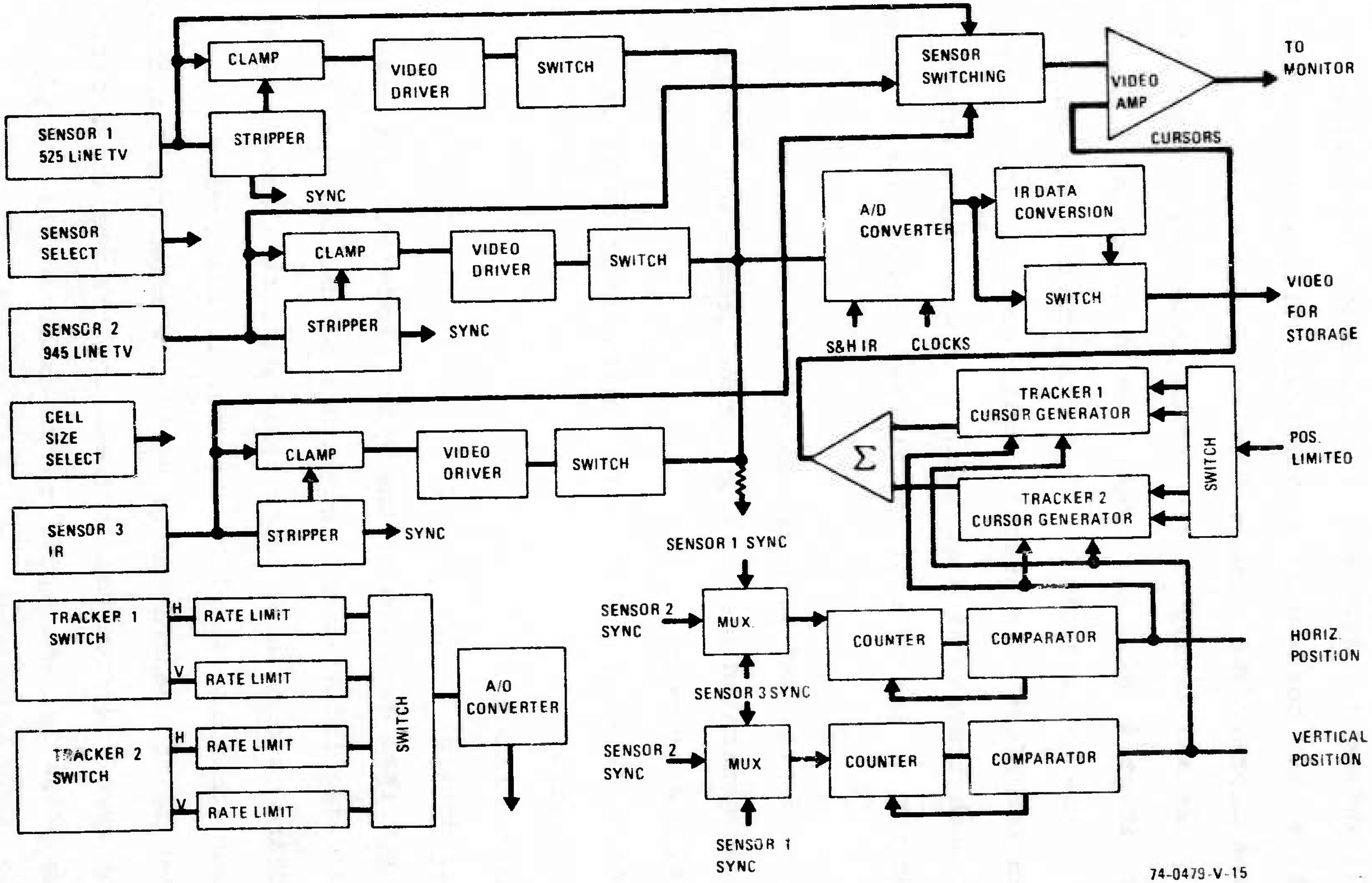


Figure 24. Front End Functional Diagram

which a pixel consists of the sum of video elements taken as a 1 x 1, 2 x 2, or 4 x 4 array, storage of these pixels, and a means of permitting access to the correlation tracker of the stored pixels.

In order to satisfy the requirements of the present program, a preliminary design effort for a video processor was undertaken in which the functional organization and definition of the constituent functions would be determined. This is the result of the preliminary design and consists of a general block diagram, a detailed block diagram, an explanation of each, and an estimate of the circuit requirements assuming the use of TTL integrated circuit logic.

6.3.2 Explanation of Processing

6.3.2.1 Summary

Figure 25 contains a general block diagram that is applicable to the video processing task for all of the required sensors. A brief explanation is given here so that the detailed explanations that follow can be built around this framework.

Referring to figure 25, the digitized video input goes to the pixel generator which, depending on the mode control instruction creates pixels consisting of 1, 4, or 16 of the digital video elements which have been summed and rounded off to the original data length. An ancillary feature required for some of the functions performed by the pixel generator is the scratch pad memory. Proper sequencing of the operations of the pixel generator is done by the process sequencer which is responsive to

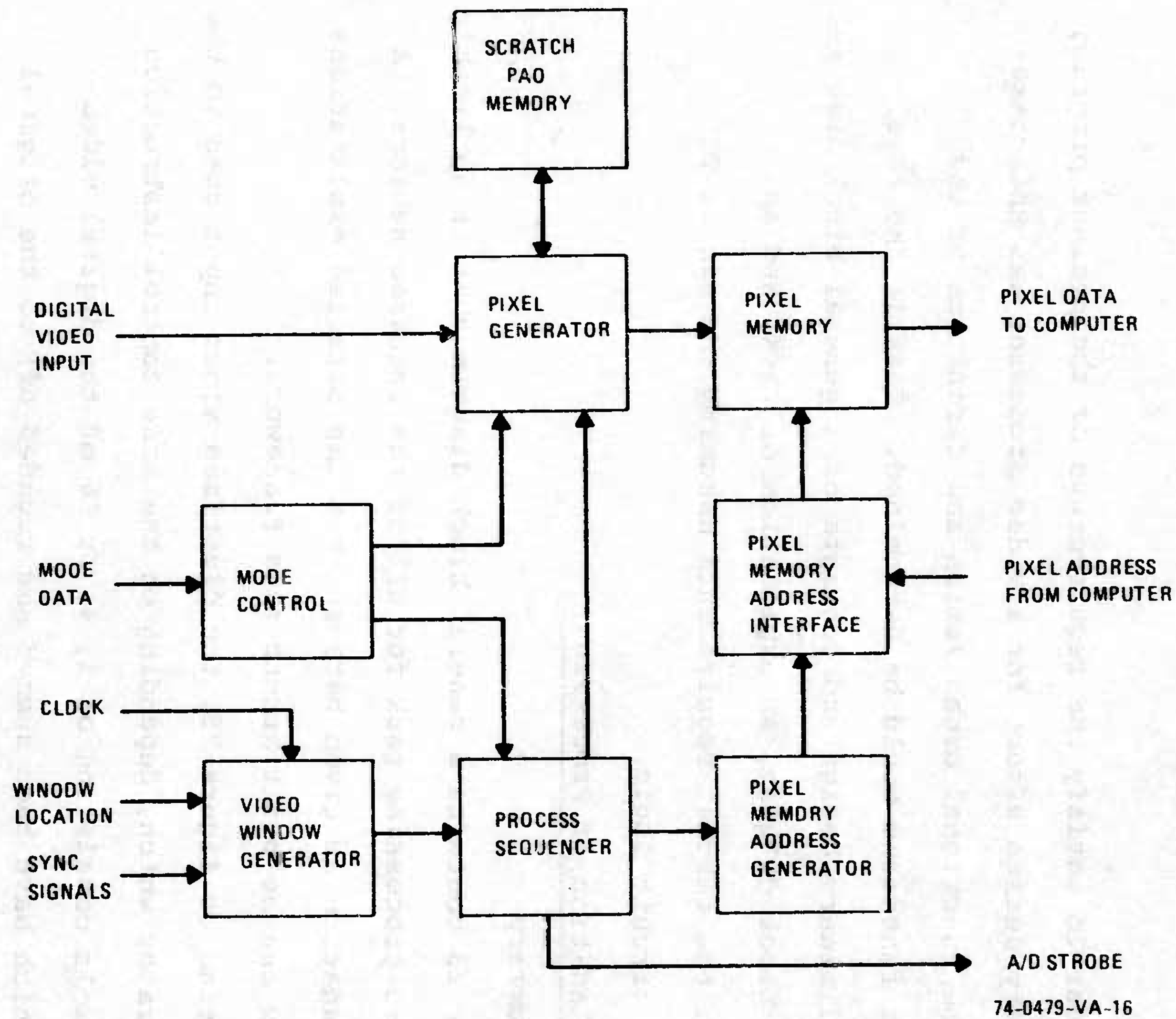


Figure 25. Digital Correlation Tracker Video Processor Block Diagram

inputs from the mode control and video window generator functions. A strobe for proper interrogation of the video analog to digital converter is also produced by the process sequencer. Inputs from the system clock, the location and size of the video window, and the sensor sync signals are used by the video window generator to establish when the video should be processed. Finally, the pixels that were created must be stored in a memory that must be both properly addressed for storage and allow access to its contents for the correlation tracker.

6.3.2.2 Television Requirements

When a television camera is used as the sensor, the primary problem for the video processor is the creation of the pixels. For this reason, a rather involved pixel generator and process sequencer were designed. As mentioned previously, a pixel will consist of either 1 x 1, 2 x 2, or 4 x 4 video elements summed and rounded off. This flexibility permits variation in the effective tracking window size while maintaining a fixed 32- by 32-element storage matrix array. Performing the sum as the video is received (corresponding to the horizontal sweep) is easy but performing the sums in the vertical direction requires a scratch pad memory because the summed data is not temporally contiguous. Pixel storage, on the other hand, is relatively simple as the address generation is straight-forward and there is adequate time for the pixel storage cycle.

Two television formats, 525 and 945 lines at 30 frames per second and 2:1 interlace, must be accommodated by the tracker.

Most of the impact of this dual format requirement with regard to the video processor is in the video window generator and the clock rate. Because the impact is so slight, the detailed block diagram explanation will not distinguish between the two formats except where absolutely necessary.

Figure 26 is the detailed block diagram of the video processor. It is basically divided into three zones, upper left which contains primarily television peculiar functions, lower left which contains infrared peculiar functions, and right which contains common functions pertaining to pixel storage.

The video processor is most easily understood by examining the pixel generation process and deriving all necessary functions and timing pulses as needed. A pixel consists of the sum of either a 1 x 1, 2 x 2, or 4 x 4 array of video elements. This is shown pictorially for the 4 x 4 case in figure 27a and 2 x 2 case in figure 27b. The 1 x 1 case is considered trivial. In the extreme upper left of figure 26 is the pixel generating function which is essentially a 4 x 4 pixel generator and which, by disabling part of it, becomes a 2 x 2 processor.

For a 4 x 4 pixel, a digitized video word (1a) is entered and is held by DATA LATCH 1. When the second video word (1b) enters, it is summed with the contents of DATA LATCH 1 in $\Sigma 1$ and this is preserved in DATA LATCH 2. The third video word (1c) is held by DATA LATCH 3 and when the fourth video word (1d) enters, it is summed with the contents of DATA LATCH 3 in $\Sigma 2$ which are summed with the contents of DATA LATCH 2 in $\Sigma 3$. The sum is held

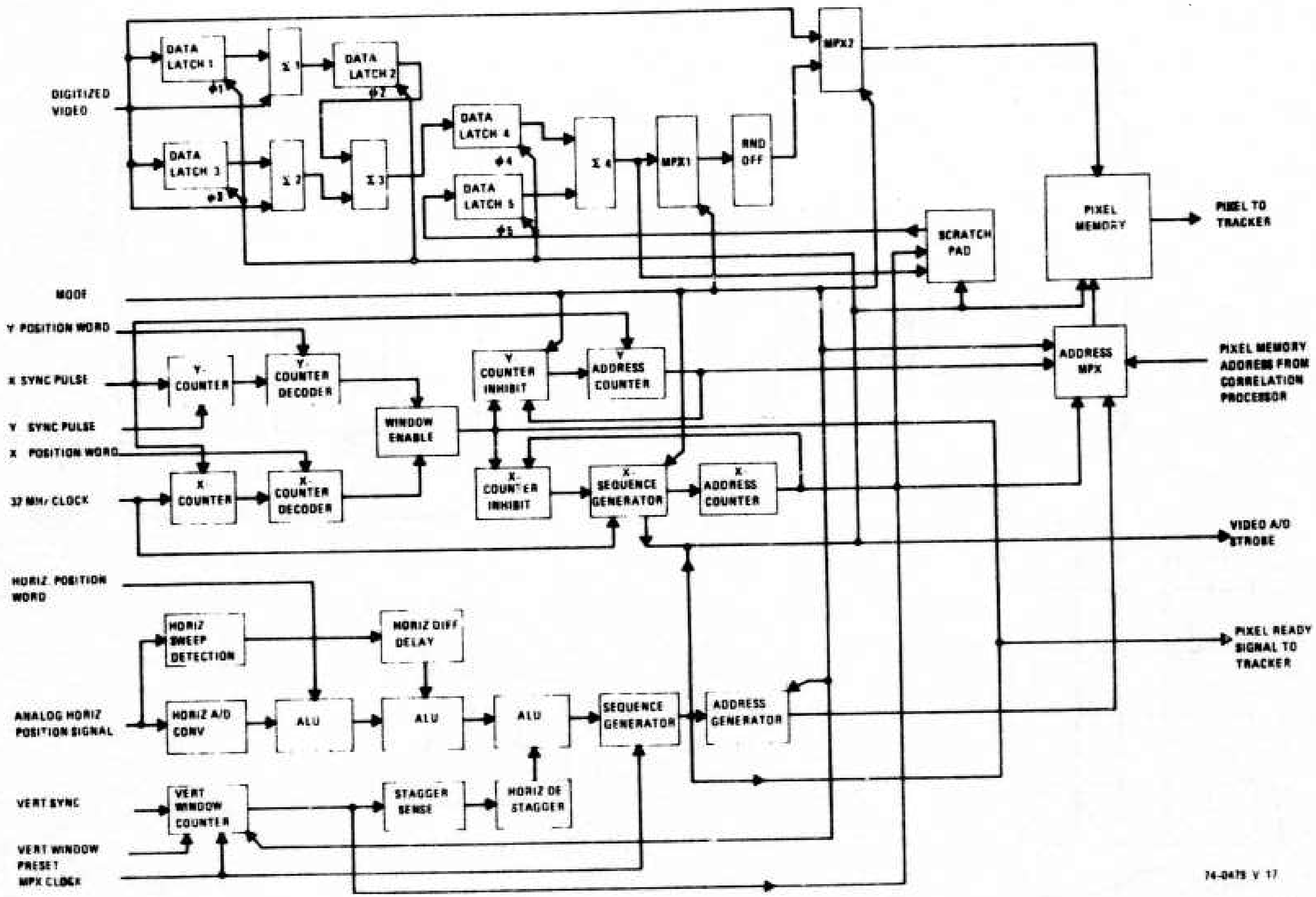


Figure 26. Detailed Block Diagram

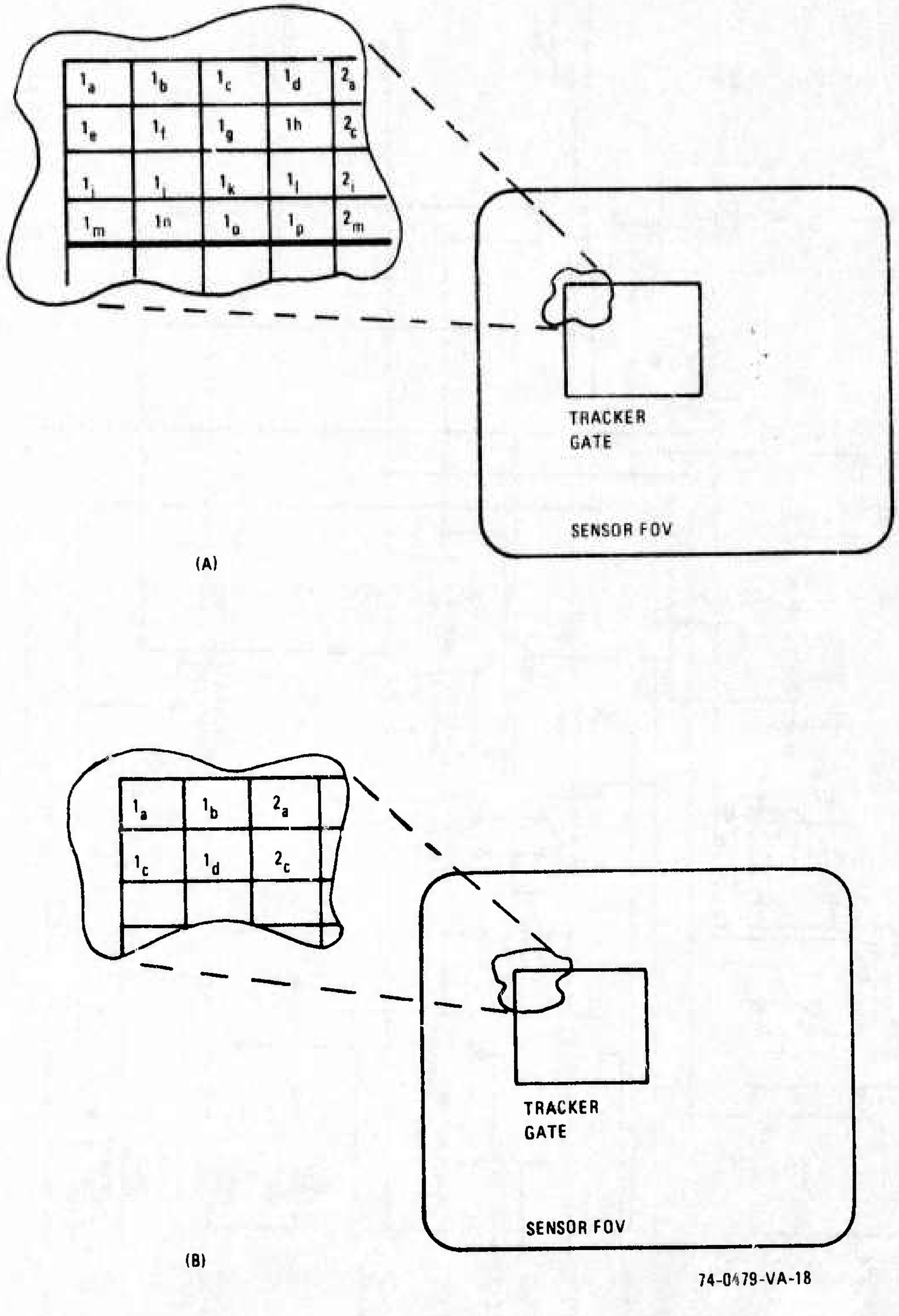


Figure 27. Pixel Partitioning

in DATA LATCH 4. For the present, assume that DATA LATCH 5 is empty and the output of $\Sigma 4$ is the same as its input. This is written in the first site of the scratch pad memory and processing begins on the next video word (2a etc.).

Referring to figure 27a, it is easily seen that the pixel is not complete but requires the sum of elements 1e through 1p. After the initial horizontal trace has been made and the retrace has occurred, video word 1e enters and the process initially described is repeated. There is one change this time though and that is when DATA LATCH 4 is strobed, the contents of the first site in the scratch pad memory are also moved into DATA LATCH 5. These are summed in $\Sigma 4$ and the resulting sum, 1a + 1b + ... + 1g + 1h, is then entered in the first site of the scratch pad.

The third trace is similar to the second and culminates with the sum of elements 1a through 1ℓ being entered in the scratch pad.

The fourth and final trace used in this pixel is similar to traces 2 and 3 except the output of $\Sigma 4$ is 1a + 1b + ... + 1o + 1p and, instead of being entered in the scratch pad, passes through MPX 1 which lines it up properly for the RND OFF which rounds the 9-bit running sum to the original data length of 5 bits and passes it on through MPX 2 from which it is finally entered in the first site of the PIXEL MEMORY.

A timing diagram in relative units of time is shown in figure 28a in which ϕi goes to DATA LATCH (i) except nothing goes to DATA LATCH 5 on trace 1.

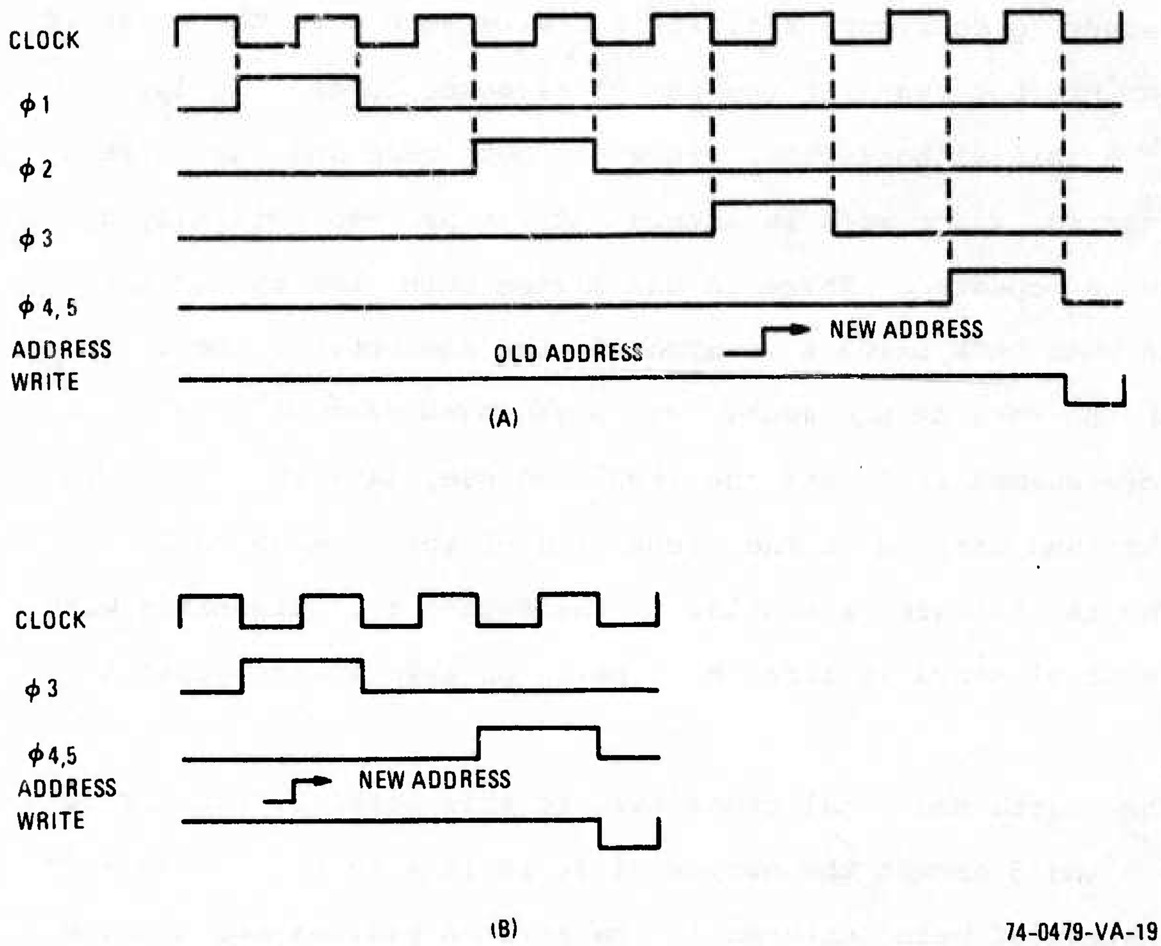


Figure 28. Sequencing Pulses for Pixel Generator

To generate pixels for 2 x 2 video word arrays as shown in figure 27b, the timing diagram is changed to the one in figure 28b in which $\phi 1$ and $\phi 2$ are zero. This results in the ultimate output of 4 being 1a + 1b +1c + 1d, a 7-bit word which needs to be re-aligned to the RND OFF function by MPX 1. The result then passes through MPX 2 and is entered in the Pixel Memory.

For the 1 x 1 case, the video words pass directly through MPX 2 and are entered in the Pixel Memory.

At this point, pixel generation has been explained and the required sequencing waveforms determined. It is now necessary to create the video window, sequencing waveforms, and memory addresses.

The video window is generated in two parts, one for the x or horizontal direction and one for the y or vertical direction. Beginning with the gate for the y-direction, a position word is received from the Correlation Processor giving the beginning coordinate of the y-window. A counter which was set to zero by the y-sync pulse counts the number of x-sync pulses, and when this number equals or exceeds the position word, a permissive or enable condition is established. A similar action is performed in the x-direction except the counter is reset on x-sync pulses and counts pulses from a 32-MHz system clock. When the x-counter reaches or exceeds the x-position word, an enable condition is also established. The simultaneous existence of both permissive conditions allows the process sequencing and address generating circuits to operate thus opening the video tracking window. A y-

permissive condition is created once per field whereas an x-permissive condition is created on every horizontal line.

Once the video window is open, the y-address counter using the mode input establishes the y-address of the pixel memory by counting the x-sync pulses. For example, in the 1 x 1 mode, each x-sync pulse advances the x-address by 1 count. In the 2 x 2 mode it takes 2 x-sync pulses to increment the y-address, and in the 4 x 4 mode, 4 x-sync pulses are required.

A similar action occurs in the x-address counter except the incrementing function is a submultiple of the 32-MHz system clock. In addition to being used to address the pixel memory, the x-address is used in the scratch pad.

Finally the sequencing waveforms must be generated. This is done most easily by using a set of tapped shift register delay lines to provide the 1 x 1, 2 x 2, and 4 x 4 modes, and the appropriate waveforms are selected via a set of parallel multiplexers for the desired mode.

The remaining two functions to be discussed for the television sensor video processing are the scratch pad and pixel memories. The former consists of a set of six 4 x 16 random access memories (RAMs) that form a 12- x 32-bit memory that is used as a 9 x 32 memory for all of the intermediate numerical processing during pixel generation. The latter is an array of five 1024 x 1 RAMs that form the 5 x 32 x 32 pixel memory. Multiple access is provided by a set of parallel multiplexers that allow addressing by either the television mode address generator, the infrared

mode address generator, or the correlation tracker after the pixel generation is complete.

6.3.2.3 Infrared Requirements

The problem of creating pixels from infrared sensor video has 4 major areas of concern. These are performing signal averaging in the horizontal sweep direction, removing the effect of the staggered detector array on the video, accommodating the bidirectional horizontal sweep, and providing a variable tracking gate without altering the signal averaging. The following paragraphs contain the recommended solution of these problems as well as a description of the remainder of the detailed block diagram.

Figure 29 shows the detector configuration with the stagger between elements. For convenience, the elements have been numbered in the order of sampling. It can now be seen that a typical video output would appear like 1, 2, 3, ... The sample rate is such that each detector element will be sampled 4 times as it is swept one detector width horizontally and consequently the element-to-element spacing in the horizontal direction is 8 samples. In addition, due to the mechanical nature of the scanning system, scans occur in both left-to-right and right-to-left directions causing a change of sense in the effect of the detector staggering. Finally, the horizontal positioning signal, a triangular wave that has been passed through a filter, has a delay with respect to the true horizontal position. A numerical value must be placed on this delay and it is to be added or subtracted from the generated horizontal address depending upon the sweep sense.

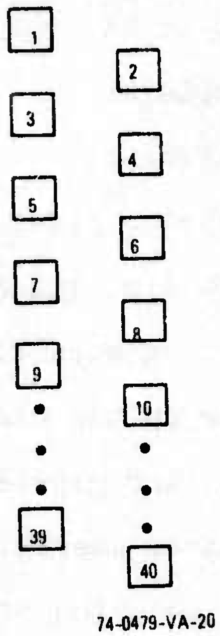


Figure 29. Sensor Configuration

The first problem area to be solved is the averaging of four successive signals from each detector element. This is done by the functions shown in the extreme upper left of figure 26 in a similar manner to the signal processing in the 2 x 2 mode when using the television sensor. There are several differences however. First, all of the required sequencing signals come from the lower left portion of the detailed block diagram. Second, the sequence of events is to store all of the first data set in the scratch pad. When the second set of data is received, the stored value is recalled, summed with the new value, and the sum is then stored in the scratch pad. This cycle continues until the final sum representing the sum of 4 bits from each detector has been made. This passes through MPX 1 and is rounded off from 7 to 5 bits, passes through MPX 2 and is stored in the pixel memory.

The solution of the problem of destaggering the video, correcting for the horizontal sweep sense and accommodating different fields of view (four) depends upon proper addressing of the pixel memory. Referring to the lower left of the detailed block diagram, it can be seen that the azimuth microsyn demodulated signal is used to determine the horizontal sweep direction and the horizontal position after being digitized in the HORIZ A/D CONV. This position is referenced to the horizontal zero position by subtracting the tracker horizontal position in the ALU (arithmetic logic unit). Following this, the differential delay resulting from filtering the horizontal position signal is added or subtracted, depending upon the sweep sense. Finally, a numerical value is added or subtracted in the last ALU to destagger the video.

This numerical value is a preselected value and the sense (+ or -) is determined by whether the incoming video word is from an odd or even numbered detector (see figure 29). To do this, the MPX CK from the sensor is counted with reference to the VERT SYNC.

Next, the vertical address is generated. Because this address requires no corrections, a simple counter that can be preset with the complement of the vertical zero position can be used. The formation of horizontal and vertical addresses initiates a READ PULSE to the video A/D CONV and the proper sequence of pulses for pixel generation.

Remaining is the implementation of a means for varying the tracking window size when tracking data from the infrared sensor. This problem differs from that encountered with the TV data. For operation with the TV data, the tracking window was increased in effective extent from its normal 32- by 32-picture elements by summing contiguous picture elements. The result was to create a tracking window of effectively 64 by 64 or 128 by 128 picture elements. Of course this was accomplished at a sacrifice in resolution since the data were still stored in a memory array of 32 by 32 cells. During operation with the infrared data, expansion of the window is unnecessary since the 32 by 32 array includes almost all of the data from the 40 infrared detector elements. In this case, the variation of the effective tracking window size must be to decrease the window extent to an effective array of 16 by 16 or 8 by 8 picture elements. This is accomplished using the basic pixel memory by modifying the address to the pixel memory. The 32- by 32-element case is simple because each memory position has a unique address. In the 16 x 16 case, only memory positions with a zero least significant bit (LSB) in both x and y are filled. Similarly, when the tracker addresses the pixel memory the LSB is assigned to be zero and hence 4 unique addresses map into each filled memory position. A similar approach is employed in the 8 x 8 case except that 2 LSB's in each address component are assigned to be zero and 16 unique addresses map into each filled memory position. Accordingly, although the correlation processor always processes a 32- by 32-element array of data, the

effective size of the tracking window is decreased by filling either 4- or 16-element groups of cells in the 32- by 32-element array with identical picture data.

6.3.3 Design

The video processor when implemented with currently available TTL functions and including a DIP 32 MHz XTAL oscillator and small 8-bit A/D will take 80 chips. It is estimated that another 4 chips will be required to alleviate output loading problems in some of the memory address circuits. This quantity of chips will occupy two circuit cards.

6.4 CORRELATION PROCESSOR

6.4.1 General Description

The operations performed in the Correlation Processor are shown in the flowchart of figure 30. The operator positions the center of the picture matrix, defined by cursors, on the target. This causes entry into the loop of figure 30. The loop index I is initialized at 0. A picture matrix is formed, representing the target with an array of 32 by 32 cells. The loop index is incremented by 1. The partial row sums and the partial column sums are formed from the contents of the picture matrix. A decision box will cause a reference to be calculated from the 16 by 16 matrix outlined by the cursors at the initiation of track. The loop index is again initialized to 0 and another picture matrix is formed on the next picture field.

During the second pass through the loop the NO path is followed from the Start decision box. A correlation calculation

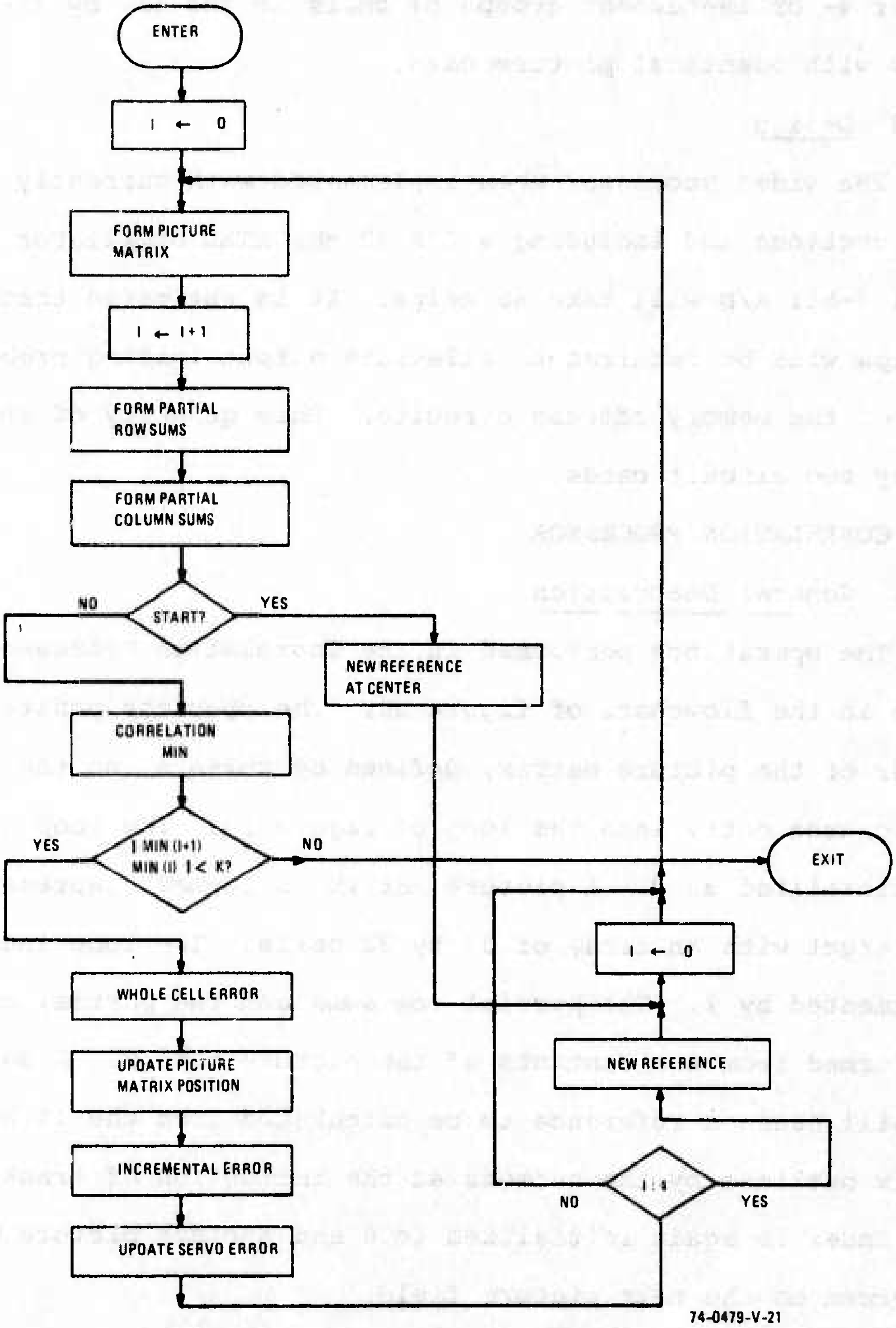


Figure 30. Correlation Processing Flowchart

is made for the central 256 of the 289 positions of the 16 by 16 reference matrix within the 32 by 32 picture matrix. The position of best correlation will have the minimum value of the correlation matrix. If the absolute difference between the new minimum and the minimum from the prior field exceeds a constant K, loop exit will occur. This exit can be used to cause a frame of picture data to be skipped and, upon repeated occurrence, to trigger a break-lock sequence. If the above is not true, the coordinates of the minimum are used to find the tracking error to the nearest integer cell. This error establishes the target picture matrix position in the next field. An incremental tracking error is then calculated and is summed with the whole cell error to update the error signal supplied to the tracking servo. A decision box will allow a new reference every 4 field periods. The loop index is then initialized to 0 and the above procedures repeated.

The following paragraphs of this section describe the processing depicted in the flowchart subsequent to the forming of the picture matrix.

6.4.2 Partial Row Sums

The processing required for obtaining the partial row sums is described with the aid of a flowchart in figure 31. The picture matrix P (I, J) is organized as a 32 by 32 array with indices I and J running from 0 to 31. In correlation with a 16 by 16 reference matrix, the sum of all 16 element rows is needed. Adjacent row sums may be found by subtracting the

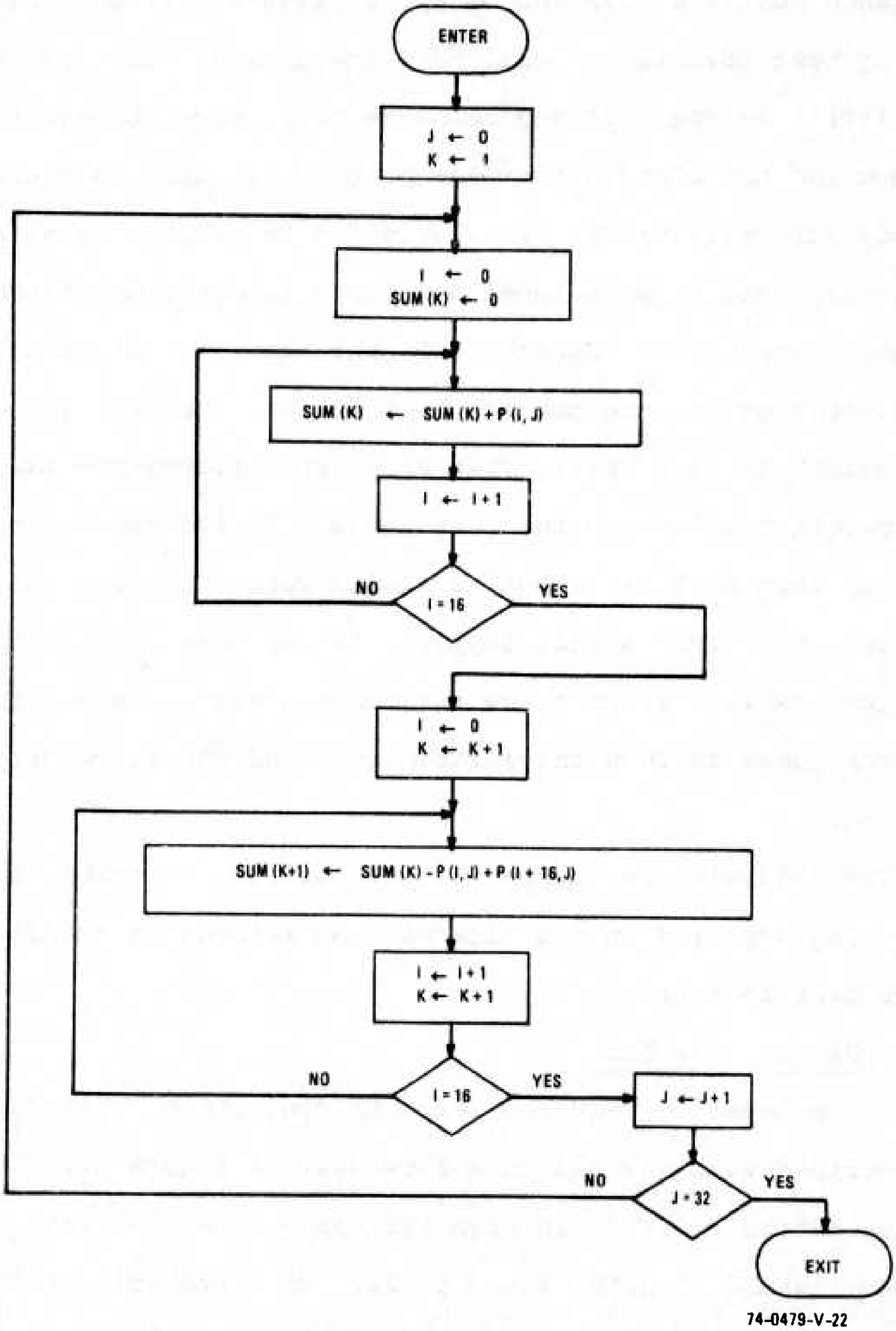


Figure 31. Flowchart for Row Sums in Correlation

left-most element and adding the next element to the right. The 16 elements need be added but once for each of 32 rows in the P matrix. This algorithm allows rapid processing. It is reflected in the flowchart of figure 31.

In figure 31, indices J and K are initialized at 0 and 1, respectively. The index I and SUM (k) are both initialized at 0. The next operation is SUM (1) ← 0 + P (0, 0). Index I is incremented by 1 and the next operation is SUM (1) ← SUM (1) + P (1, 0). This process continues until all 16 elements have been summed. At this stage, I = 16. Next, I is reset to 0, and index K is incremented by 1. The following operation is SUM (2) = SUM (1) - P (0, 0) + P (16, 0). The value of SUM (2) is obtained from SUM (1) by a subtraction and an addition. Indices I and K are incremented by 1 and the process repeats until I = 16. This completes the production of the partial sums in the first row of the P matrix. Index J is incremented by 1, a test is made to see if J = 32, and the process repeats as shown. The partial sums in the second row of the P matrix are computed. The iterations will cease when the partial sums in all 32 rows of the P matrix are calculated which is indicated by J = 32.

The operations described by the flowchart of figure 31 are readily implemented with logic chips. Figure 32 shows a proposed scheme. The numbers in the lower right hand corner of some of the blocks refer to the number of binary bits required. The number of bits in the hardware chosen will usually exceed that number because many chips are available only in 4 bits. The 32 by

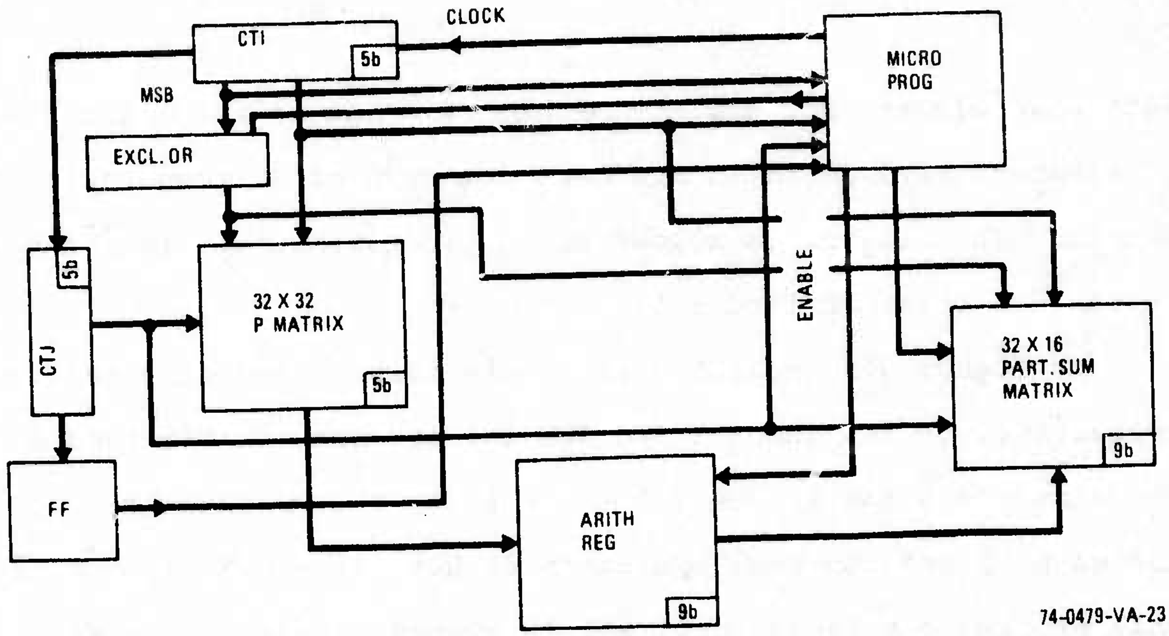


Figure 32. Implementing Partial Row Sums

32 P-matrix was selected to have dimensions conforming to natural binary numbers. Two binary 5-bit counters, CTI and CTJ, may be used with the output of CTI connected to the input of CTJ as shown in figure 32. A clock will operate CTI producing the sequence of I and J states depicted in figure 31. The counter states of CTI and CTJ will access the P-matrix RAM and PART SUM matrix RAM. An exclusive or (EXCL OR) gate will invert the most significant bit (MSB) of CT I when required by the program contained with the MICRO PROG box. The ARITH REG will add or sub- numbers as directed by the MICRO PROG box.

CTI and CTJ are initially preset to 0. The MSB or binary 16 in CTI will indicate the subprogram used. When the MSB is ZERO, for 16 clock periods, the contents of the addressed cells in the P-matrix will be added and accumulated. When the MSB becomes a ONE, the prior partial sum is stored in the cell addressed in the PART SUM matrix by CTJ and CTI minus 16. CTI minus 16 is obtained

by inverting the MSB of CTI in the EXCL OR circuit. The above address is also used to fetch a number from the P-matrix RAM which is subtracted from the prior partial sum. CTI and CTJ will fetch a number from the P-matrix to add to the previous difference. This value is the next partial sum. The process continues until CTI overflows and returns to a state of all zeroes at which time CTJ is incremented and the cycle repeats. The process iterates until CTJ overflows and sets the flip-flop F-F, signaling the microprogram to stop.

The operations for obtaining the partial column sums are the same as those explained except that counters CTI and CTJ are interchanged in fetching data from the P-matrix.

The following estimate of the required hardware to implement these functions cites generic names. Counters CTI and CTJ may each be built from a 9316, 4-bit counter, and a single flip-flip such as 1/2 of a type 9020. The EXCL OR circuit will be a 7486. The P-matrix is mentioned elsewhere in this report and will be 5 type 93415 RAMs. The PART SUM matrix will be 9 type 93415 RAMs. The ARITH REG will be 3 type 9340 ALUs. The MICRO PROG will consist of some PROMs such as Intersil IM5600C, a 9316 counter, 9020 J-K flip-flops, and 7400 2-input NAND gates.

6.4.3 Correlation Calculation

The 512 partial sums of rows and 512 partial sums of columns are stored in adjacent memory cells as they are calculated. The next operation is fetching the correct sums from memory to subtract from the reference vector sums as required in the correlation

algorithm. There are 256 positions of the reference matrix within the 32 by 32 P-matrix for which correlations are performed.

The correlation process involves subtracting the partial sums of rows and columns in each picture 16 by 16 submatrix from the corresponding values for the reference. The absolute values are found for these 32 numbers and they are totaled to produce a value of the simplest correlation matrix. The process of correlation devised performs the subtracting of the rows from the row reference in parallel with the subtracting of the columns from the column reference and combines the results. This reduces the time required to complete the correlation matrix by about a factor of 2 as compared with sequential operations on row and column partial sums.

Table XIII lists the relative memory cell locations of the row partial sums and the column partial sums needed for correlations 1, 2, 16, and 17 out of total of 256.

Table XIII - Memory Addresses Used in Correlation

Correlation Number	Partial Row Sum	Partial Column Sum
1	(0,0),(0,1),(0,2),-- (0,15)	(0,0),(0,1),(0,2),--(0,15)
2	(1,0),(1,1),(1,2),--(1,15)	(0,1),(0,2),(0,3),--(0,16)
↓ 16	(15,0),(15,1),(15,2),--(15,15)	(0,15),(0,16),(0,17),--(0,31)
17	(0,1),(0,2),(0,3),--(0.16)	(1,0),(1,1),(1,2),--(1,15)

These are sufficient in number to indicate a pattern that can be generated by a cascaded group of binary counters. Figure 33 shows

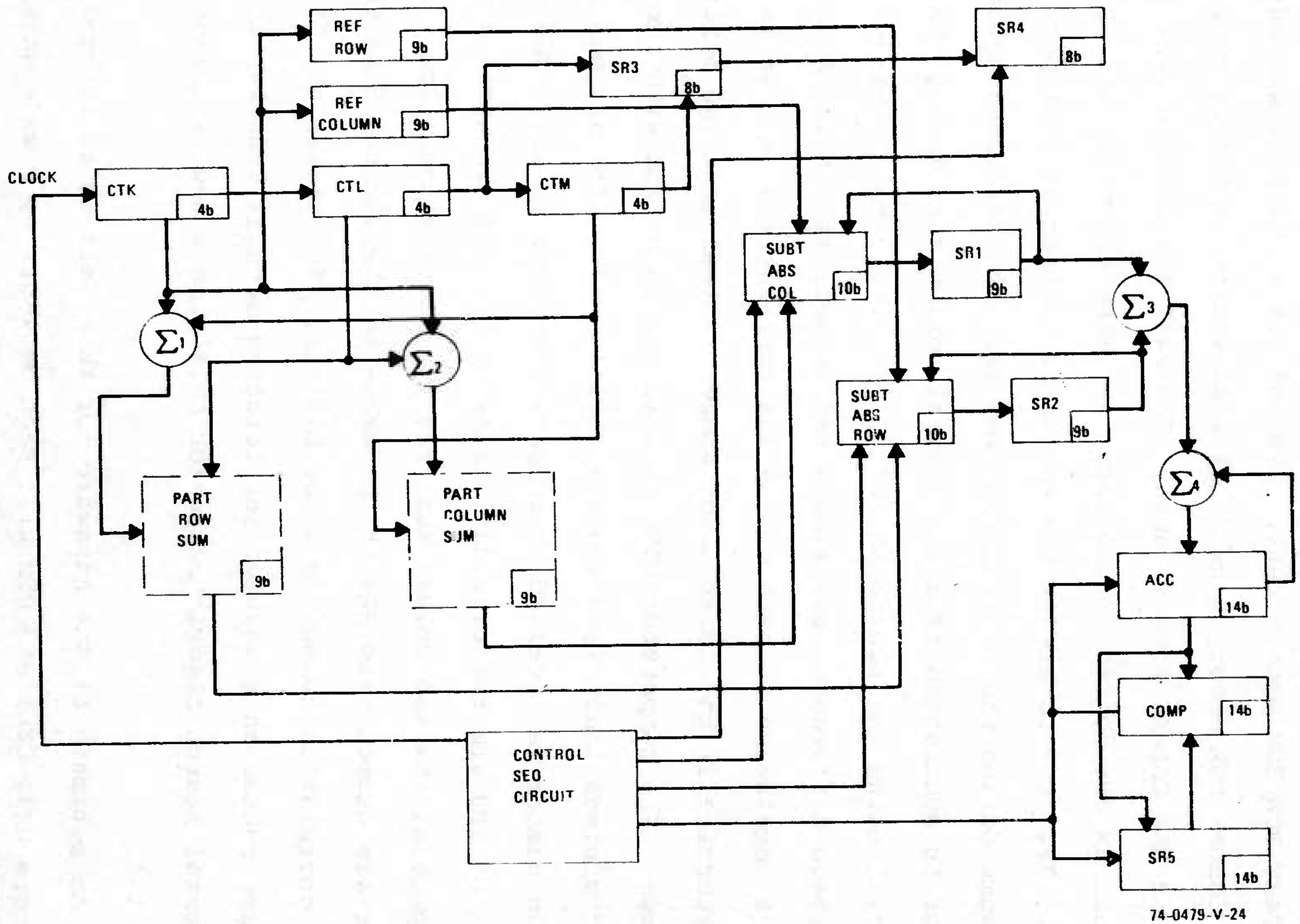


Figure 33. Fetching Partial Sums in Correlation

how 3 binary counters CTK, CTL, and CTM are connected to fetch the partial row and column sums from memory. Each counter is a 4-bit up counter. CTL in conjunction with CTK + CTM will address the PART ROW SUM memory bank. CTM and CTK + CTL will address the PART COLUMN SUM memory bank. CTK also addresses the 16 by 1 REF ROW and REF COLUMN memory banks. The PART ROW SUM and PART COLUMN SUM blocks are dotted to indicate they were shown previously in figure 32. The reference row vector is subtracted from partial row sums during the correlation process. The reference column vector is subtracted from the partial column sums during the same interval using the scheme in figure 33. The absolute values of the above differences are summed and accumulated in the ACC block. At the completion of each of the 256 correlations, a test is made to determine if the correlation number is less than the prior minimum. The comparator COMP is used for this test with the prior minimum input from storage register SR5. The minimum correlation number is retained in temporary storage in SR5. The contents of SR3 are the original states of CTL and CTM used in fetching partial row and column sums for the correlation. These contents are dumped into SR4 if the above test indicates that the last correlation number is a new minimum. The states of CTL and CTM are needed as a pointer for fetching partial sums in the incremental search algorithm and for obtaining a new reference every 4 fields.

An estimate of the hardware for this [illegible] is as follows. Counters CTK, CTL, and CTM will each be 4-bit up-down counters,

type 74193, with provision for direct presetting. The two summing circuits designated by $\Sigma 1$ and $\Sigma 2$ will each be 2, type 7483, full adders. The PART ROW SUM and PART COLUMN SUM memory banks were mentioned previously and will each consist of 9, type 93415, RAMs. The REF ROW and REF COLUMN memory banks will each consist of 3, type 7489, RAMs. The SUBT ABS COL and SUB ABS ROW blocks will each comprise 3, type 9340, ALUs and 6, type 9322, multiplexers. The 2 storage registers SR1 and SR2 that follow are each 2, type 74174, hex D flip-flops. The two summing devices $\Sigma 3$ and $\Sigma 4$ are each 3, type 7483, full adders. The accumulators designated ACC will be 3, type 74174, units. The comparator COMP is 3, type 9324, chips. SR5 will consist of 3, type 74174, chips. SR3 and SR4 are each 2 chips of the 74174 variety. The CONTROL SEQ CIRCUIT will contain several Intersil IM5600C PROMs, a 9316 counter, several 9020 chips, and 2 type 7400 NAND gates.

6.4.4 Incremental Error

The algorithm to derive the incremental error allows finding the tracking error to a quantum of 1/8 of a cell. The first step in the process is the calculation of an xu(i) vector from the equation:

$$xu(i) = rx(i) + rx(i + 1) - 2\, x^*(i + 1),\ i = 1,\ldots,15$$

where rx(i) is the reference vector and $x^*(i + 1)$ is the vector comprising partial sums that were used in finding the minimum correlation number. Figure 34 illustrates the mechanization for finding xu(i). The blocks designated TX and x^* are dotted to show they were shown previously in figure 33. rx is contained in REF

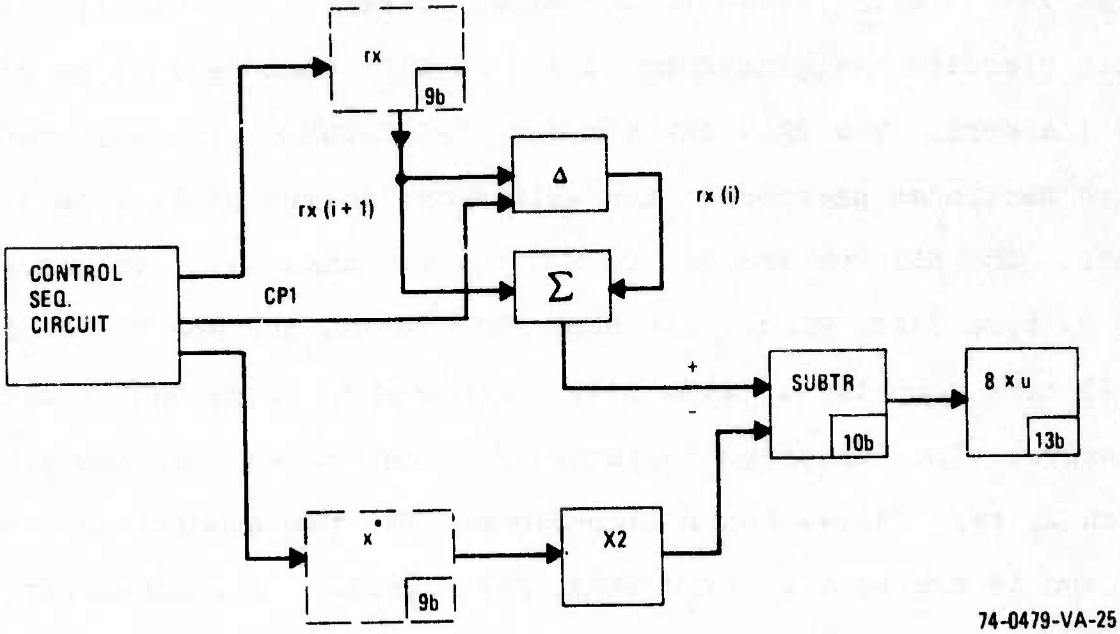


Figure 34. Computation of Xu Vector

ROW or REF COLUMN blocks in figure 33. X* is fetched from either the PART ROW SUM or PART COLUMN SUM memory banks in figure 33.

The control sequential circuit contains binary counters that provide access to rx(i) and x*(i) components in memory banks. A unit delay circuit, Δ, provides an output rx(i) that is summed with its input rx(i + 1) in an adding circuit designated by the Σ symbol. This connects to the positive input of a subtracting circuit which has a minus input from 2x*(i + 1) retrieved from memory. The quantity 8xu is stored in a memory bank.

The rx and x* symbols are shown within memory blocks previously described. The unit delay element Δ will be 2, type 74174, hex D flip-flops. The add symbol Σ will be implemented with 3, type 7483, full adders. The subtracting circuit called SUBTR will be built with 3 ALU type 9340 chips. The block designated 8xu will be 4 of type 7489 RAMS. The CONTROL SEQ CIRCUIT will consist

of several Intersil IM5600C type PROMs, a 9316 counter, some 9020 J-K flip-flops, and 2, type 7400, NAND gates.

The second step is finding the xv vector:

$$xv(i) = 2\ (x^*(i) - x^*(i+1)),\ i = 1,\ldots,15$$

The proposed implementation for finding xv(i) is depicted in figure 35 where the block x* refers to a portion of the memory cells in either the PART ROW SUM or PART COLUMN SUM of figure 33.

The control sequential circuit consists of binary counters that recall x*(i) from memory. A unit delay bank of flip-flops, Δ, provides a delayed output. A subtracting circuit develops the required difference which is multiplied by 2 by displacing each bit one position. The output vector xu is entered into a memory bank designated xv for use in the last step in the process.

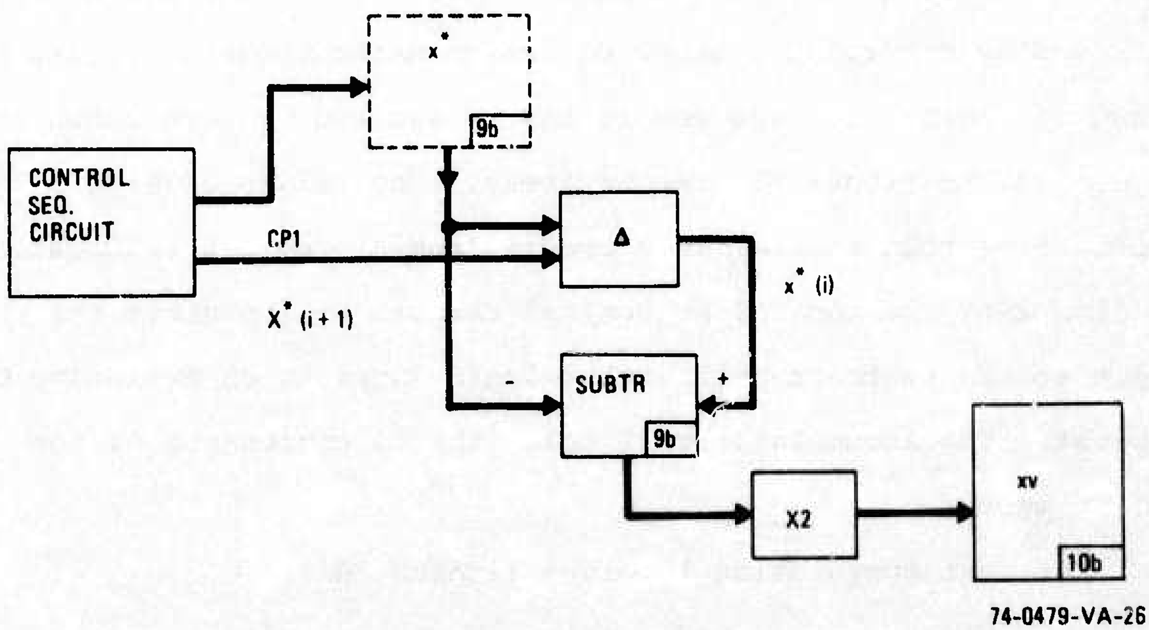


Figure 35. Computation of Xv Vector

The implementation may be estimated for this processor. The unit delay element, Δ, will be 2, type 74174, hex D flip-flops. The subtracting circuit SUBTR will be 3 ALU 9340 units. The multiply by 2 function is obtained by displacing outputs of the SUBT unit by 1 bit. The CONTROL SEQ CIRCUIT will contain 2, type IM5600C, PROMs, 1 counter, type 9316, serial flip-flops of the 9020 variety, and 2, type 7400, NAND gates.

The final step in the process involves the equation below:

$$d(k) = \sum_{i=1}^{15} \left| Sik \right| .$$

$$k = 0, \ldots 8$$

$$Si,o = 8xu(i)$$

$$Si,k = Si,k-1 - xv(i) \text{ for } k = 1, \ldots 8$$

The k associated with the minimum value of d(k) will define the incremental error. The means of implementing these equations are shown in figure 36. The memory blocks 8xu and xv were shown in figure 34 and figure 35, respectively. The values of Si,o = 8xu(i) have been entered into memory from a previous calculation. To find d(o) the control sequential circuit will inhibit the xv input to the subtract unit with a logic input to an exclusive OR circuit. The accumulator will total the 15 components of the 8xu(i) vector.

The next computation involves finding d(1) =

$$\sum_{i=1}^{15} \left| Si, o - xv\ (i) \right|$$

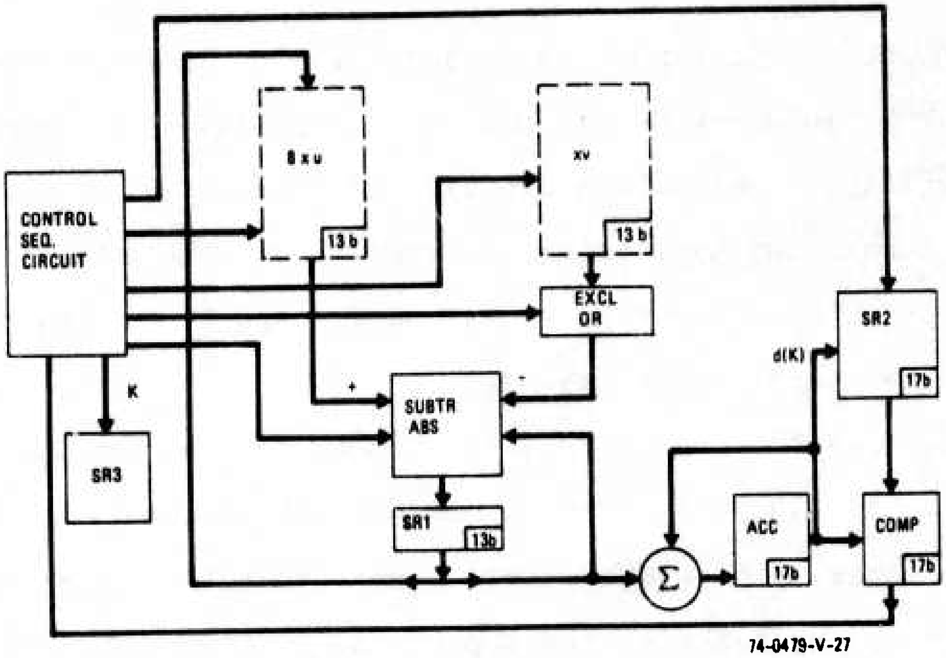


Figure 36. Computation of d(k)

The values of Si,o and xv(i) are accessed from memory with the CONTROL SEQ CIRCUIT. The difference is entered back into the memory bank previously holding Si,o for use in finding d(2). The absolute value of the difference is accumulated. The value of d(1) in the accumulator ACC is compared with d(0) contained in SR2 using comparator COMP. The minimum value of d(k) is retained in SR2 and the corresponding value of k is entered into memory SR3.

An estimate of the required chips for this unit is as follows. The dotted memory blocks designated 8xu and xv were discussed earlier. The SUBTR ABS circuit will consist of 4 ALU 9340 units. SR1 will be 3, type 74174, hex D flip-flops. The summing circuit Σ is constructed of 5, type 7483, full adders. The accumulator ACC will be 3, type 74174, units. The storage register SR2 will also be 3, type 74174, chips. The comparator

will consist of 5, type 9324, chips. SR3 will be 1, type 74174, unit. The exclusive OR circuit, EXCL OR, will be 4 chips of the 7486 variety. The CONTROL SEQ CIRCUIT block will consist of 3, type Intersil IM5600C, PROMs, 2, type 9316, counters, several J-K flip-flops of the 9020 type, and 2, type 7400, NAND gates.

6.4.5 Functional Block Diagram

The order of the correlation processing was described in the flowchart of figure 30. The block diagram of figure 37 shows how the separate microprocessors described are interconnected. The five memory banks at the top of the diagram are shown separately because they are shared by the individual processors. Data is passed from one to another. Using data from the picture matrix the PARTIAL ROW SUM and PARTIAL COLUMN SUM memory banks are assembled and used both by the CORRELATION and INCREMENTAL SEARCH processors. As a result of the correlation calculation a whole bit error is developed to reposition the P-matrix in the FOV for the next scan. Every 4 picture fields the REF ROW and REF COL memory banks are updated with a new reference vector obtained from the correlation calculation.

The incremental search is performed using all memory banks with the exception of the picture matrix. The incremental error is combined with the whole bit error from the correlation operation and after conversion to analog format is routed to the tracker servo system.

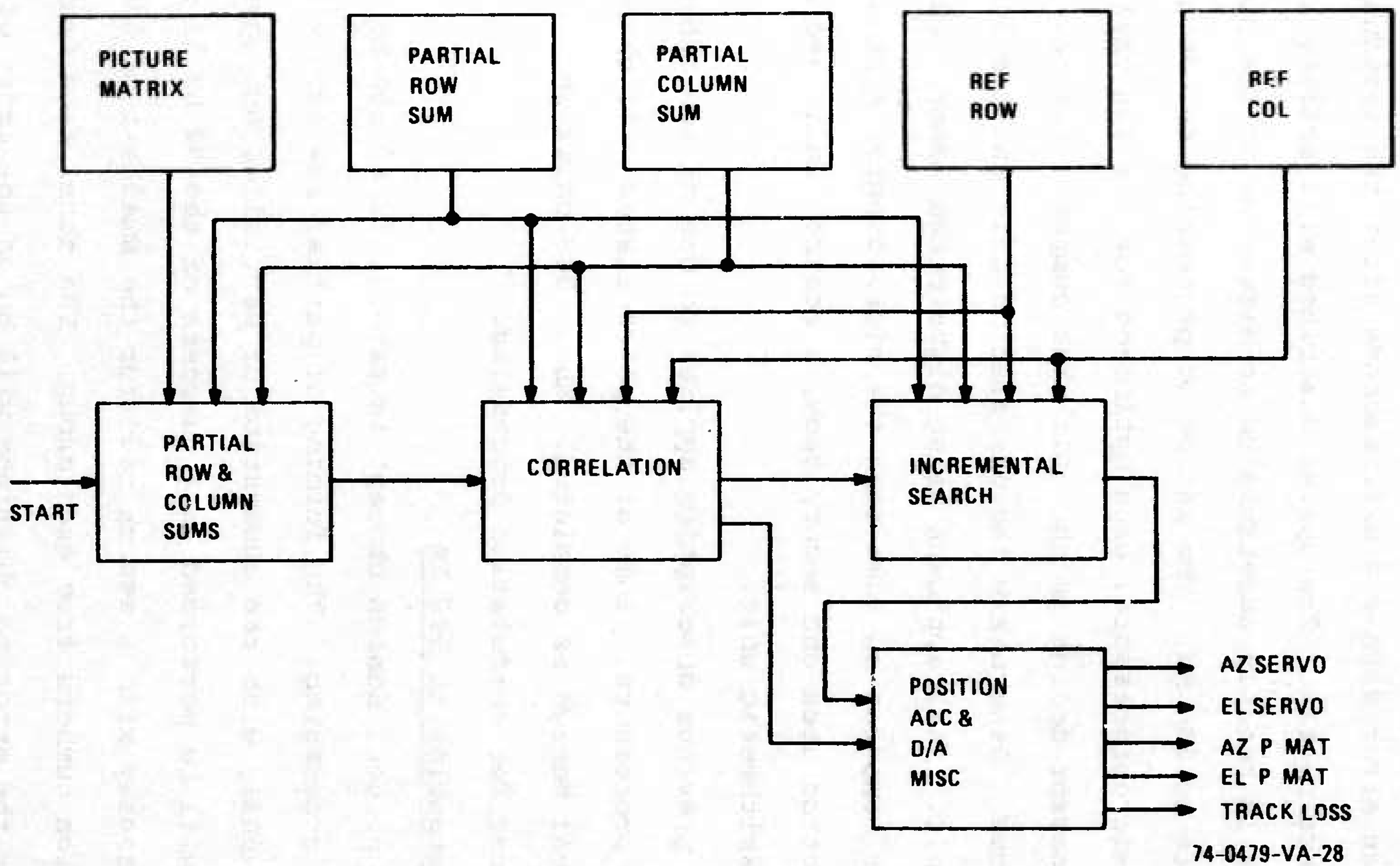


Figure 37. Correlation Tracker Block Diagram 1 Channel

6.4.6 Summary

The prime requirement for the correlation processing is to produce an error within 4 milliseconds after the termination of the picture matrix. The system described will satisfy this condition. It is readily adaptable to an extension of the picture field rate to 500 Hz. The method of processing selected has several microprocessors, each optimized for its own task. One microprocessor design is the unit that computes partial row and column sums. Others are the correlation unit and the incremental search unit. This approach using distributed memory resulted in a shorter computation time than the microcomputer approach. The latter method uses one memory bank, a control unit, and a general-purpose arithmetic unit.

The previous description applies to one of two identical tracking processors. Some of the parts listed will change when the logical design is completed. About 200 chips per tracker will be required for correlation processing.

6.4.7 Extension to 500 Hz

The present design concept is extendable to 500 Hz with parallel processing. The forming of partial row sums will be done simultaneously with the generation of partial column sums. Correlations will be performed on 4 quarters of the 32 by 32 matrix simultaneously with a search made for the smallest of the minimum correlation numbers from each group. The total time from beginning to end of the error calculations will be on the order of 1 millisecond.

SECTION VII

CONCLUSIONS

The previous sections have detailed the problem, the theory and implementation of the tracking algorithms, the formation of the tests, and the resultant data derived from real sensor sequential image data. This section presents some conclusions that can be drawn relative to the comparative performance of the different tracking configurations on that data. Based on a critical examination of the data, a general conclusion that can be drawn is that the correlation tracker is the most precise.

Other specific conclusions are as follows:

- In terms of jitter performance (rms radial error), best performance is obtained from the correlation tracker followed in order by the centroid and edge trackers. In general, the performance of the edge tracker is inferior. Table XIV summarizes the relative performance of the correlation and centroid trackers in terms of relative noise reduction of the correlation over the centroid tracker.
- The spectral density calculations and plots indicate that for the correlation and centroid trackers most of the energy occurs at very low frequencies and is more typical of random wander rather than jitter. The variance is generally greater

Table XIV

Noise Reduction of Correlation Tracker Relative to Centroid Tracker

Run No.	Noise Reduction (dB)	
80	-12.9	
82	- 3.3	
84	- 3.5	
86	- 8.5	
88	- 1.52	Stationary Test Target
90	+ .33	Stationary Test Target
92	- 2.2	
94	- 4.1	

(i.e., the spectrum is spread more) for the centroid and edge trackers.

- Tests have shown that the track window position can be placed over different points on a given target with essentially the same performance for the correlation tracker and with performance values that vary as a function of position for the edge and centroid trackers.
- The correlation and edge trackers require no operator inputs of threshold level or contrast sign determination; the performance of the centroid tracker depends upon operator choice of these parameters (although, with added complexity, the process can be automated for almost all cases).
- Drift error or change in track point for the correlation and centroid trackers are comparable, small, and sometimes better for the centroid tracker. Drift error in the

correlation tracker is related to the update scheme. Skipping of a number of frames has been shown to produce less drift than averaging over a number of frames to produce the reference. This problem has not been completely resolved and it is expected that better update algorithms other than those tested will be found; performance at present is considered good but can be improved.

- To achieve some of the better data for the centroid and edge trackers, some form of channel gain compensation would be required. In some cases, without gain compensation, the low gains of the centroid and edge trackers would produce an unlock condition in a closed loop system.
- In addition to the specific tests made on stationary targets, the reference program capability is shown by data derived from different measures (correlation with marginals and sum of absolute values, centroid, and edge) on the same data.
- The simplified correlation tracker algorithm employed in the tracker CSP can be implemented with computation times of less than 4 milliseconds for a frame rate of 120 Hz.
- The design configuration lends itself to formation of simple parallel structures for extension to a 500-Hz frame rate.

SECTION VIII

RECOMMENDATIONS

The development of the Computer Simulation Package during the Phase I effort has provided a tool which serves to predict the performance achievable with various tracking systems. Several measures of tracker performance in terms of rms jitter, drift, and error spectral density are provided as outputs. Further effort is required to verify the predicted efficiency of the correlation tracker. Comparison of predicted and actual tracker performance is recommended to obtain this verification. This can be accomplished by comparison of the predicted performance of the correlation tracker with that of a tracker mechanization developed during the next program phase.

Of the correlation tracker algorithms investigated, the single iteration exhaustive search using the absolute value metric operating on marginal vector data is recommended for mechanization in the second phase. The exhaustive search enables the target to be found anywhere in a 32-by 32-element window processed by the tracker. This search is made possible within the limitations imposed by the sensor frame time by the use of the absolute value metric which simplifies the types of calculations and by using the marginal vector data which represents a 16-by 16-element scene by two 16-element vectors instead of a 256-element matrix array.

The originally proposed gradient search approach was found to lead to frequent loss of track on a target in a complex background environment. The multiple iteration approach with successive searches with gradually improving resolution minimized the number of calculations and thus permitted the highest operating speed. However, the performance attained with this technique was less satisfactory since the target was occasionally lost in tbe low-resolution search. Also, the variety of the calculations required a mechanization of the correlation processor amounting to a minicomputer. A computer such as the Digital Equipment Corporation PDP 11/45 would perform the necessary calculations at the rates desired.

The cost of the digital correlation tracker mechanization can be reduced, however, through selection of the simpler single interation algorithm described in this report. This mechanization is recommended for development and evaluation during the second phase of the program.

APPENDIX I

CORRELATION BASED ON THE MINIMIZATION OF A DISTANCE METRIC

Suppose two n element picture representation vectors r and p are given where the component values r_i and p_i are functions of position coordinates (x, y); that is, the vectors are represented by

$$
\begin{aligned}
& r_i(x, y);\ i = 1, ---, n \\
& p_i(x, y)
\end{aligned}
\tag{142}
$$

Let the vector r be measured at the reference coordinates (x_0, y_0) and let the vector p be measured at coordinates (x, y) where

$$
\begin{aligned}
x &= x_0 + \delta \\
y &= y_0 + \varepsilon
\end{aligned}
\tag{143}
$$

and ε, δ are small.

It is assumed that for small displacements δ, ε the norm of the p vector is constant and related to the reference vector norm according to

$$||p(x, y)|| = c||r(x_0, y_0)|| \tag{144}$$

where c is a positive constant.

The assumption employed here is that for small displacements about the track point (x_0, y_0), the pictures within the track window have the same intensity norms although they may be spatially displaced.

The square distance (square of the Euclidian distance) $d^2(x_0, y_0, x, y)$ is given by

$$d^2(x_0, y_0, x, y) = ||r(x_0, y_0) - p(x, y)||^2 \tag{145}$$

By equation (143), let

$$d^2(\delta, \varepsilon) = d^2(x_0, y_0, x, y) \tag{146}$$

Expanding equation (5),

$$d^2(\delta, \varepsilon) = \sum_{i=1}^{n} [r_i(x_0, y_0) - p_i(x, y)]^2 \tag{147}$$

$$d^2(\delta, \varepsilon) = \sum_{i=1}^{n} r_i^2(x_0, y_0) - 2\sum_{i=1}^{n} r_i(x_0, y_0)p_i(x, y) + \sum_{i=1}^{n} p_i^2(x, y) \tag{148}$$

By definition of the norm,

$$||r(x_0, y_0)||^2 = \sum_{i=1}^{n} r_i^2(x_0, y_0)$$

$$||p(x, y)||^2 = \sum_{i=1}^{n} p_i^2(x, y) \tag{149}$$

Further, the cross-correlation between the vectors r and p for the displacements δ, ε given by $\rho(\delta, \varepsilon)$ is given by

$$\rho(\delta, \varepsilon) = \frac{\sum_{i=1}^{n} r_i(x_0, y_0) p_i(x, y)}{||r(x_0, y_0)|| \cdot ||p(x, y)||} \tag{150}$$

By equations 148, 149, and 150,

$$d^2(\delta, \varepsilon) = ||r(x_0, y_0)||^2 - 2||r(x_0, y_0)|| \cdot ||p(x, y)||\rho(\delta, \varepsilon) + ||p(x, y)||^2 \tag{151}$$

And from equation 144,

$$d^2(\delta, \varepsilon) = ||r(x_0, y_0)||^2[1 - 2c\rho(\delta, \varepsilon) + c^2] \tag{152}$$

or

$$d^2(\delta, \varepsilon) = (1 + c^2)||r(x_0, y_0)||^2 \cdot [1 - \frac{2c}{1 + c^2}\rho(\delta, \varepsilon)] \tag{153}$$

Since $c > 0$, then

$$0 < \frac{2c}{1 + c^2} \leq 1 \tag{154}$$

Finally, $d^2(\delta, \varepsilon)$ is minimized if and only if $\rho(\delta, \varepsilon)$ is maximized indicating that both measures are equivalent.

Calculations according to equation 147 are still formidable because of the necessity of computing square values. To overcome this difficulty, the absolute value distance measure

is employed instead of the square measure in equation 147; that is,

$$\bar{d}(\delta, \epsilon) = \sum_{i=1}^{n} |r_i(x_0, y_0) - p_i(x, y)| \tag{155}$$

A search is then performed to determine δ^*, ϵ^* so that

$$\bar{d}(\delta^*, \epsilon^*) \leq \bar{d}(\delta, \epsilon) \tag{156}$$

over the search range

$$\begin{aligned} x_1 &\leq \delta, \delta^* \leq x_2 \\ y_1 &\leq \epsilon, \epsilon^* \leq y_2 \end{aligned} \tag{157}$$

Appendix II

POWER SPECIAL DENSITY CALCULATIONS

It is assumed that the measured error values from a random process are given by $x(t)$, $t \epsilon \{0,T\}$. The autocorrelation function $\phi(\tau)$ for this process is given by

$$\phi(\tau) = \frac{1}{T} \int_0^T x(t)\, x(t-\tau)\,dt \tag{158}$$

The power spectral density, $G(f)$, for the random process is defined as the Fourier transform of the autocorrelation function; hence,

$$G(f) = \int_{-\infty}^{\infty} \phi(\tau)\, e^{-j2\pi f\tau}\,d\tau \tag{159}$$

The autocorrelation function is symmetric so that

$$\phi(-\tau) = \phi(\tau) \tag{160}$$

Further, by expanding equation (159),

$$G(f) = \int_{-\infty}^{\infty} \phi(\tau)\cos(2\pi f\tau)\,d\tau - j\int_{-\infty}^{\infty} \phi(\tau)\sin(2\pi f\tau)\,d\tau \tag{161}$$

By equation (160),

$$G(f) = 2\int_0^{\infty} \phi(\tau)\cos(2\pi f\tau)\,d\tau \tag{162}$$

The process is measured over the interval $(0,T)$ and it is assumed that

$$\phi(\tau) = 0,\ t > T\ , \tag{163}$$

so that

$$G(f) = 2\int_0^T \phi(\tau)\cos(2\pi f\tau)d\tau \tag{164}$$

Rather than being continuous as in equation (158), the data are given at time intervals t_n where

$$t_n = nT_o = n/f_s \tag{165}$$

where T_o = sample period = 1/sample rate = $1/f_s$.

For m input samples, the period T is given by

$$T = mT_o \tag{166}$$

and displacements τ_k are in increments of T_o so that

$$\tau_k = kT_o \tag{167}$$

With the above, equation (158) is approximated by a sum such that

$$\phi(kT_o) = \frac{1}{m} \sum_{n=0}^{m-1} x(nT_o)x(nT_o-kT_o) \tag{168}$$

Now, for $a < o$ then

$$x(a) = o \tag{169}$$

and

$$\phi(kT_o) = \frac{1}{m} \sum_{n=k}^{m-1} x(nT_o)\, x\{(n-k)T_o\} \tag{170}$$

$$k = o, \ldots, m-1$$

Similarly, the expression in equation (164) is also approximated by a sum given in terms of frequency increments f_k where

$$f_k = kf_s/120;\ k = 0,1,..,60 \tag{171}$$

and

$$G(\frac{kf_s}{120}) = 2/f_s \{\phi(0) + 2 \sum_{n=1}^{m-1} \phi(nT_o)\cos(2\pi\frac{kn}{120}) \tag{172}$$

In examining the data, the mean value of the error $\overline{x}$ is subtracted from each of the measurements; $\overline{x}$ is given by

$$\overline{x} = \frac{1}{m} \sum_{n=0}^{m-1} x(nT_o) \qquad (173)$$

and a modified error value $y(nT_o)$ is given by

$$y(nT_o) = x(nT_o) - \overline{x} \qquad (174)$$

For the above, equation (170) is modified to:

$$\phi(kT_o) = \frac{1}{m} \sum_{n=k}^{m-1} y(nT_o)\, y\{(n-k)T_o\} \qquad (175)$$

Finally, it is noted that

$$\phi(o) = \sigma^2 = \text{sample variance of the process} \qquad (176)$$

and $$\sigma^2 = \frac{f_s}{120} \sum_{k=o}^{60} G\left(\frac{kf_s}{120}\right) \qquad (177)$$

Appendix III

TRACKER PERFORMANCE: NOISE AND DRIFT

The performance of each of the tracker types can be assessed on the basis of two statistics: (1) the rms. variation of the track point (track point "jitter") and, (2) drift of the track point from initial values. Both of the above are determined from a linear regression analysis given below.

It is assumed that measurements are made over n data frames. For a given data frame k, the measurement error in one channel, x_k, is assumed given by

$$x_k = g(t_k) + \epsilon_k \tag{178}$$

where ϵ_k is a random variable assumed independent and identically distributed. The function g is assumed linear and given by

$$g(t_k) = \alpha + \beta\,(t_k - \bar{t}\,) \tag{179}$$

where $\bar{t}$ is the mean of the t_k values.

From an analysis given in Lindgren*, unbiased estimates of α, β, and σ^2 are given by:

---

*B. W. Lindgren, Statistical Theory, The MacMillan Co., New York, 1966, pp. 360-362.

$$\hat{\alpha} = \frac{1}{n}\sum_{k=1}^{n} x_k = \text{mean error}$$

$$\hat{\beta} = \frac{\sum_{k=1}^{n} x_k(t_k-\bar{t})}{\sum_{k=1}^{n}(t_k-\bar{t})^2} = \text{regression coefficient}$$

(180)

$$\hat{\sigma}^2 = \frac{1}{n}\sum_{k=1}^{n}[x_k - \hat{\alpha} - \hat{\beta}(t_k-\bar{t})]^2 = \text{sample variance}$$

$$\bar{t} = \frac{1}{n}\sum_{k=1}^{n} t_k$$

$$n = \text{number of frames.}$$

Since the frame rate is constant, the formulas of equations (180) can be rewritten in terms of the number of frames and are given by:

$$\hat{\alpha} = \bar{x} = \frac{1}{n}\sum_{k=1}^{n} x_k$$

$$\hat{\beta} = \frac{\sum_{k=1}^{n} kx_k - \frac{n(n+1)}{2}\bar{x}}{\frac{n}{12}(n^2-1)} \qquad (181)$$

$$\hat{\sigma}^2 = \frac{1}{n}\sum_{k=1}^{n} x_k^2 - \bar{x}^2 - \hat{\beta}^2\left(\frac{n^2-1}{12}\right)$$

The drift distance for a given channel, d, is given by

$$d = \hat{\beta} n \tag{182}$$

Calculations are made for each channel and may be combined as follows:

$$\hat{\sigma} \text{ radial} = \sqrt{\hat{\sigma}_x{}^2 + \hat{\sigma}_y{}^2} \tag{183}$$

The above is a figure of merit combining the jitter noise of both channels. A total drift distance, d_t, is similarly given by

$$d_t = \sqrt{d_x{}^2 + d_y{}^2} = n\sqrt{\hat{\beta}_x{}^2 + \hat{\beta}_y{}^2} \tag{184}$$

APPENDIX IV

TV IMAGERY DATA

The following pages of this appendix present the frames of TV imagery data which were processed as described in Section 4 of this report. Digital imagery information was derived from these frames for input to the Computer Simulation Package. In paragraph 4.2.3 the four separate imagery data runs, numbers 2 through 5, were described. These particular segments of the imagery supplied by AFWL were selected to provide varying backgrounds, target aspects and contrasts. Each data run consists of six groups of 21 sequential frames of imagery. The first of these runs, number 2, consists of scenes with the target flying in front of a clear background sky. The fuselage is darker than the background and the foreshortened sunlit wings brighter. The first 21 frames of this data run were input to the CSP for computer runs numbers 30 and 31 and 39 through 43 which were discussed in paragraph 5.1. Both the wing section and nose of the target aircraft were tracked during these computer simulation runs. In the final tracker performance evaluation, computer run number 80 also used data run number 2 with 100 frames being processed during this tracker comparison run. Data from this and the other final production runs of the CSP are presented in Appendix V with a summary analysis in Section 5. During computer run number 80 the trackers tracked the wing section of the aircraft.

Data run number 3 containing imagery of an aircraft target turning against a clear sky background was used for computer run number 82. During this run the three tracker algorithms were compared to evaluate their performance tracking the nose of the aircraft for 48 frames of the imagery data.

In computer run number 84, imagery data run number 1 was used. This run contained the same frames of imagery processed as data run number 4 but without the time code display along the left margin of the scene. In this sample of imagery the aircraft is flying in front of a mountainside background. Comparative tracker performance was evaluated for 96 frames with the trackers tracking the dark aircraft tail section.

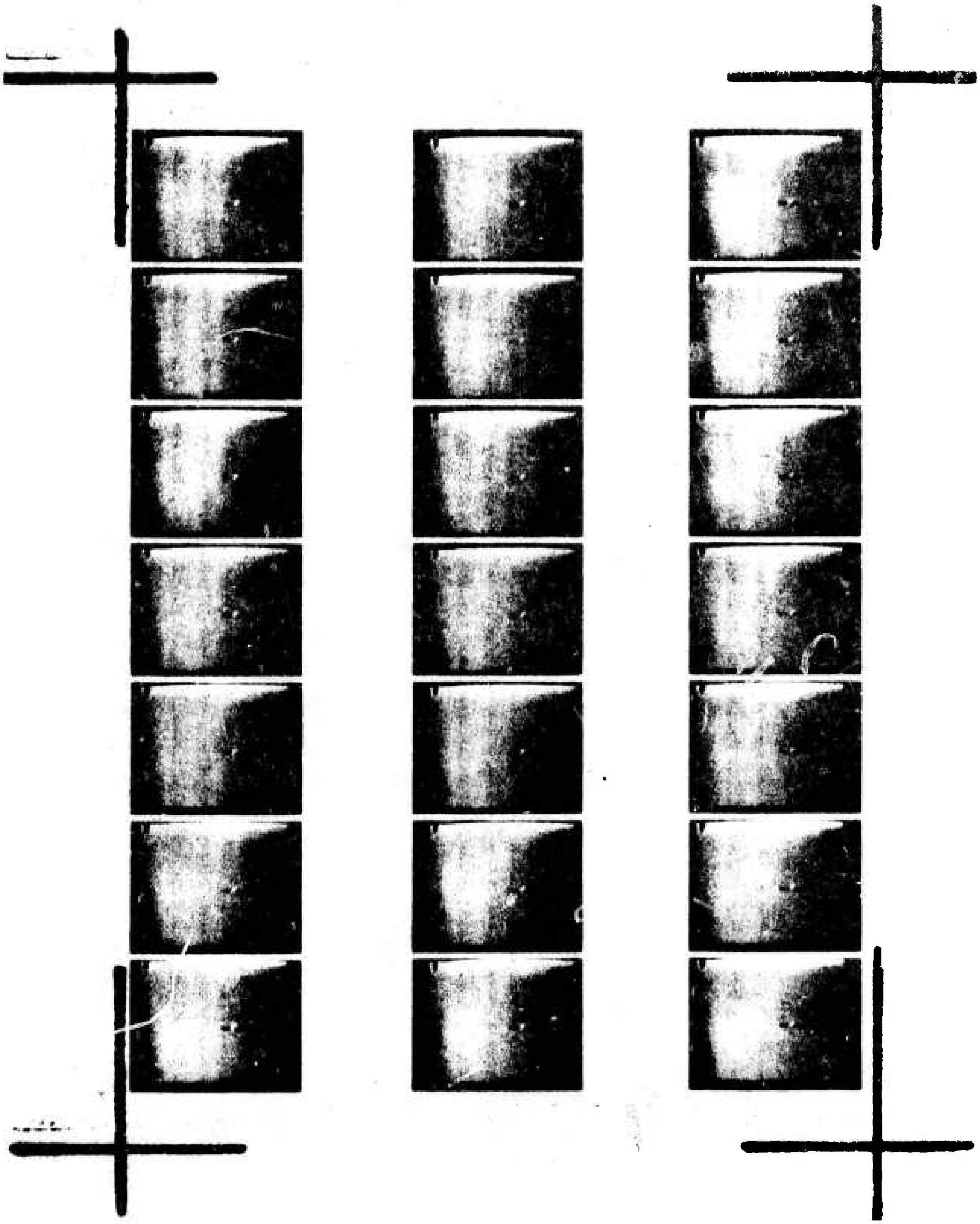
The final data run, number 5, was used for computer run number 86. In this imagery the aircraft climbs across the mountain horizon and turns to provide a changing aspect. Tracker performance was compared for 98 frames while tracking the aircraft nose.

Data Run No. 2

TV Sensor

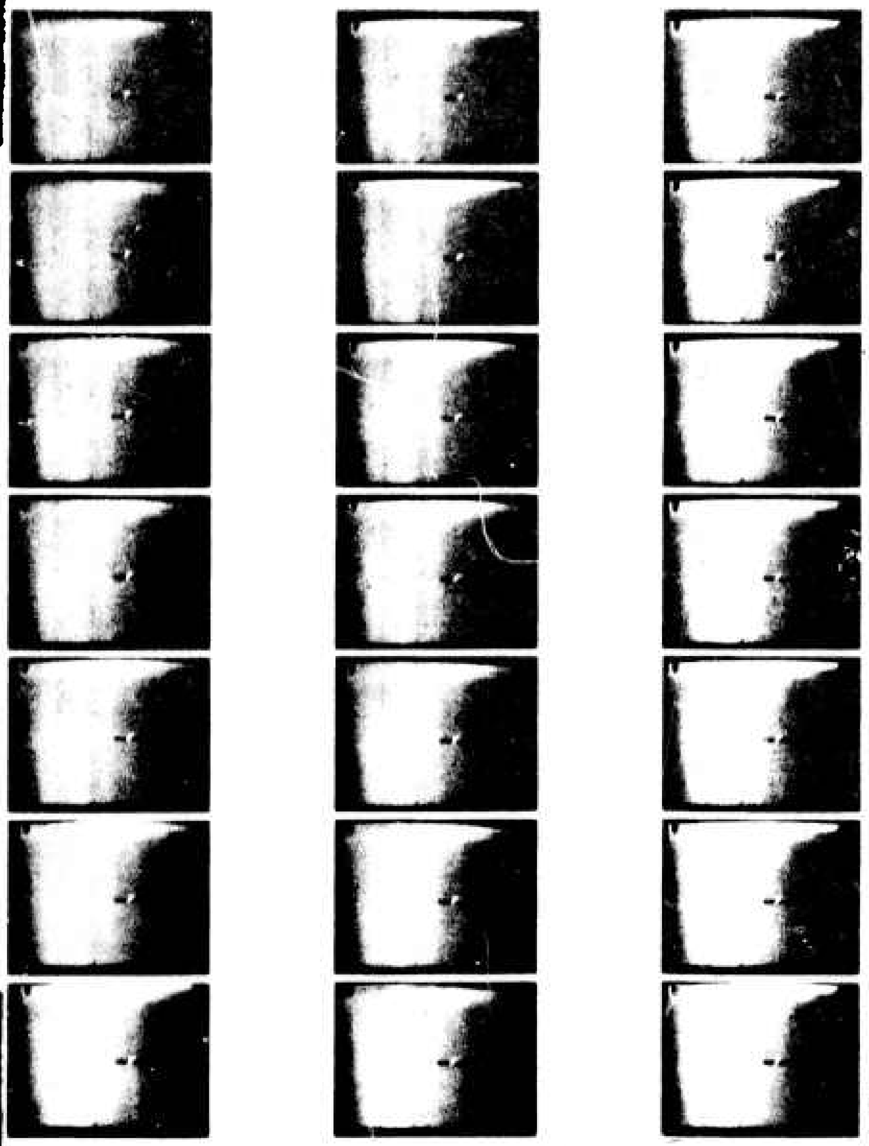
Aircraft Target

Level Flight - Sky Background



S74-0425-PA-4

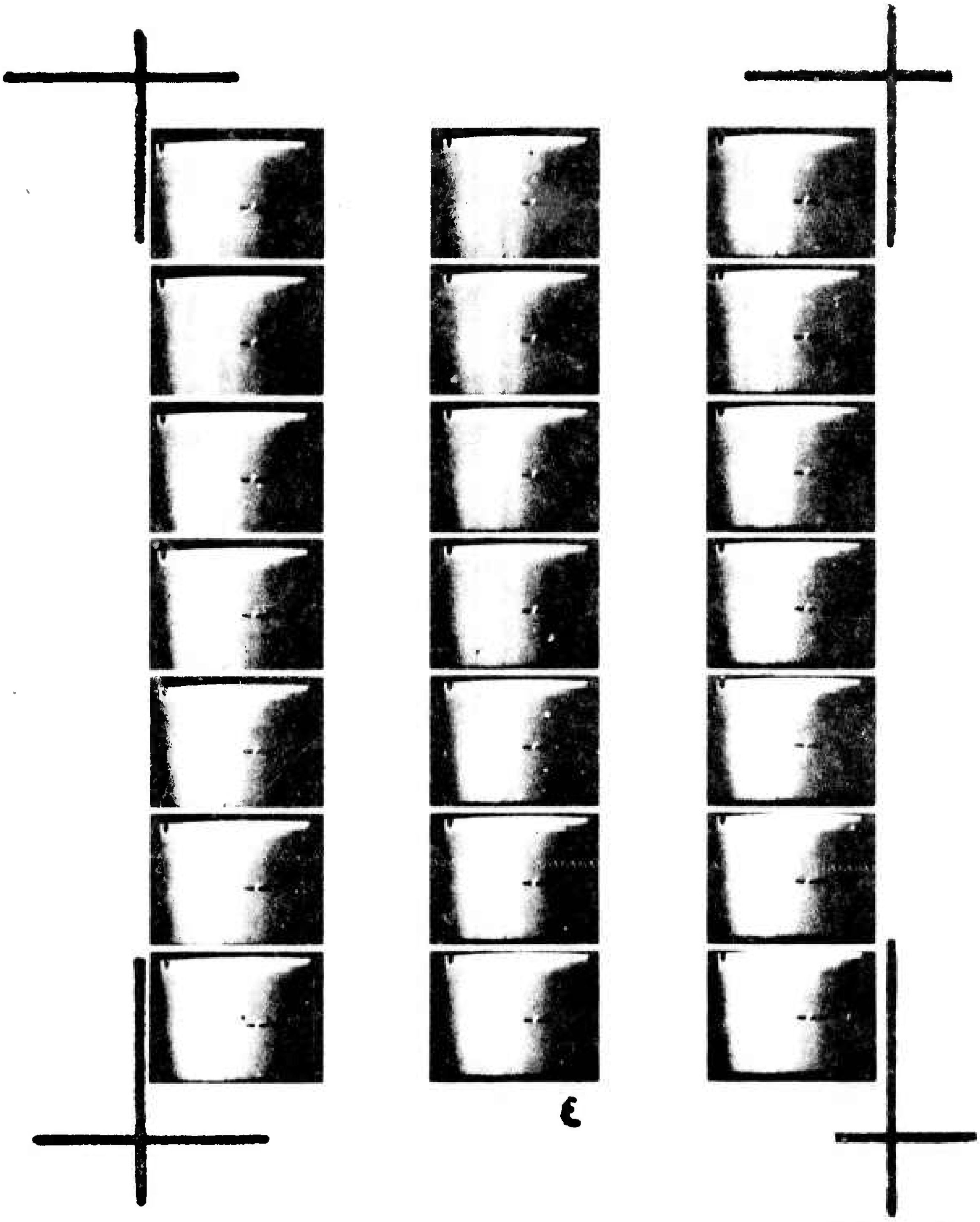
Run 2; Frames 1 to 21



S

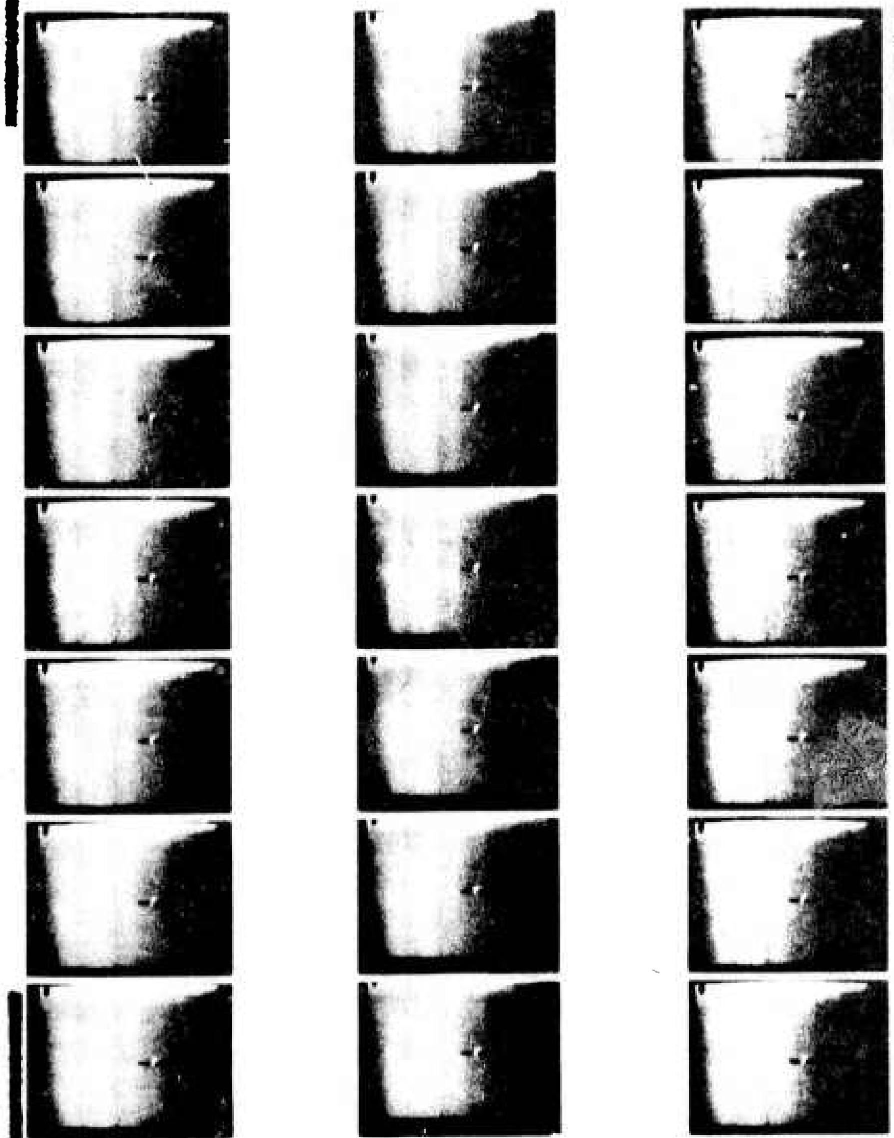
74-0479-PA-29

Run 2; Frames 22 to 42



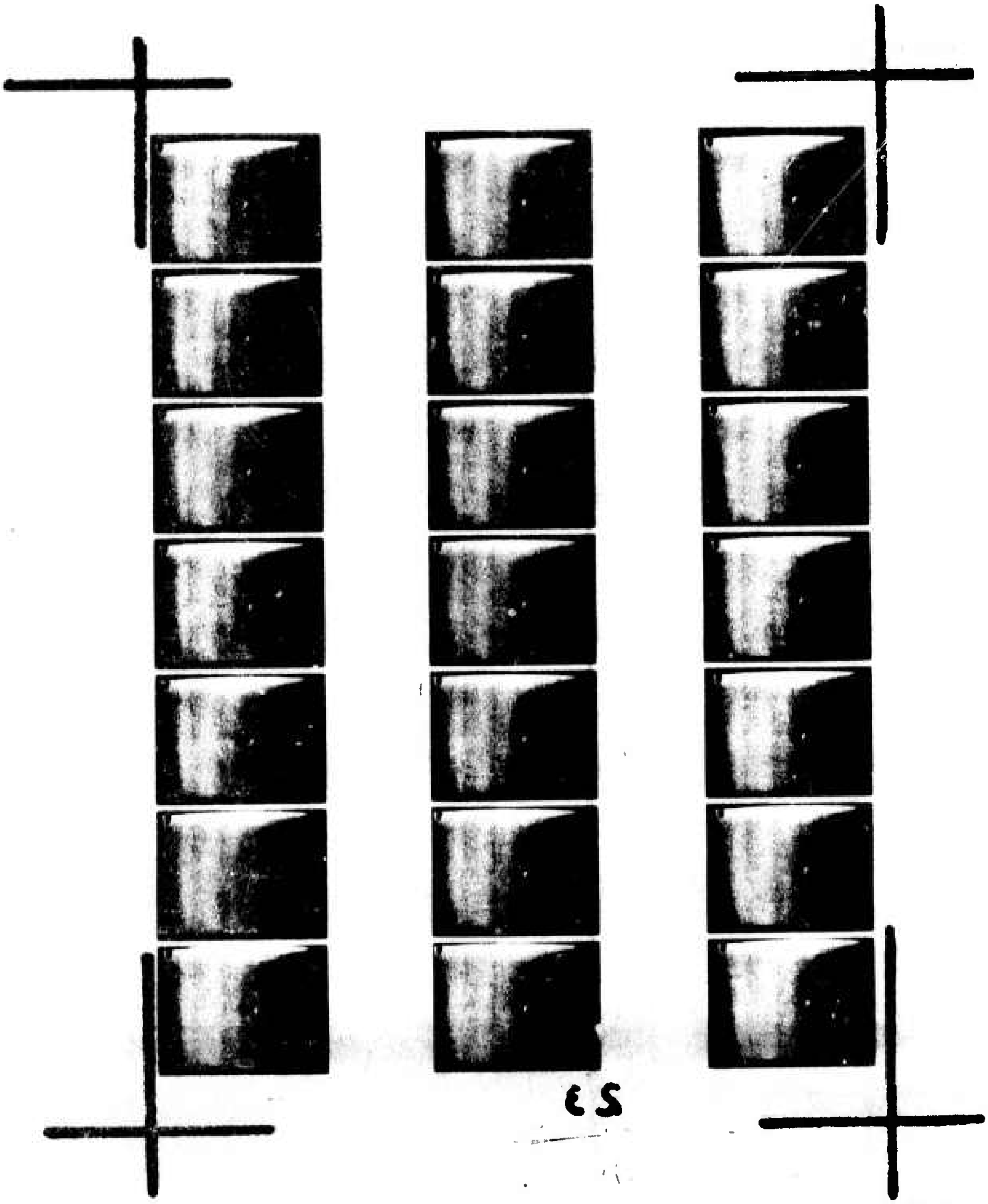
74-0479-PA-30

Run 2; Frames 43 to 63



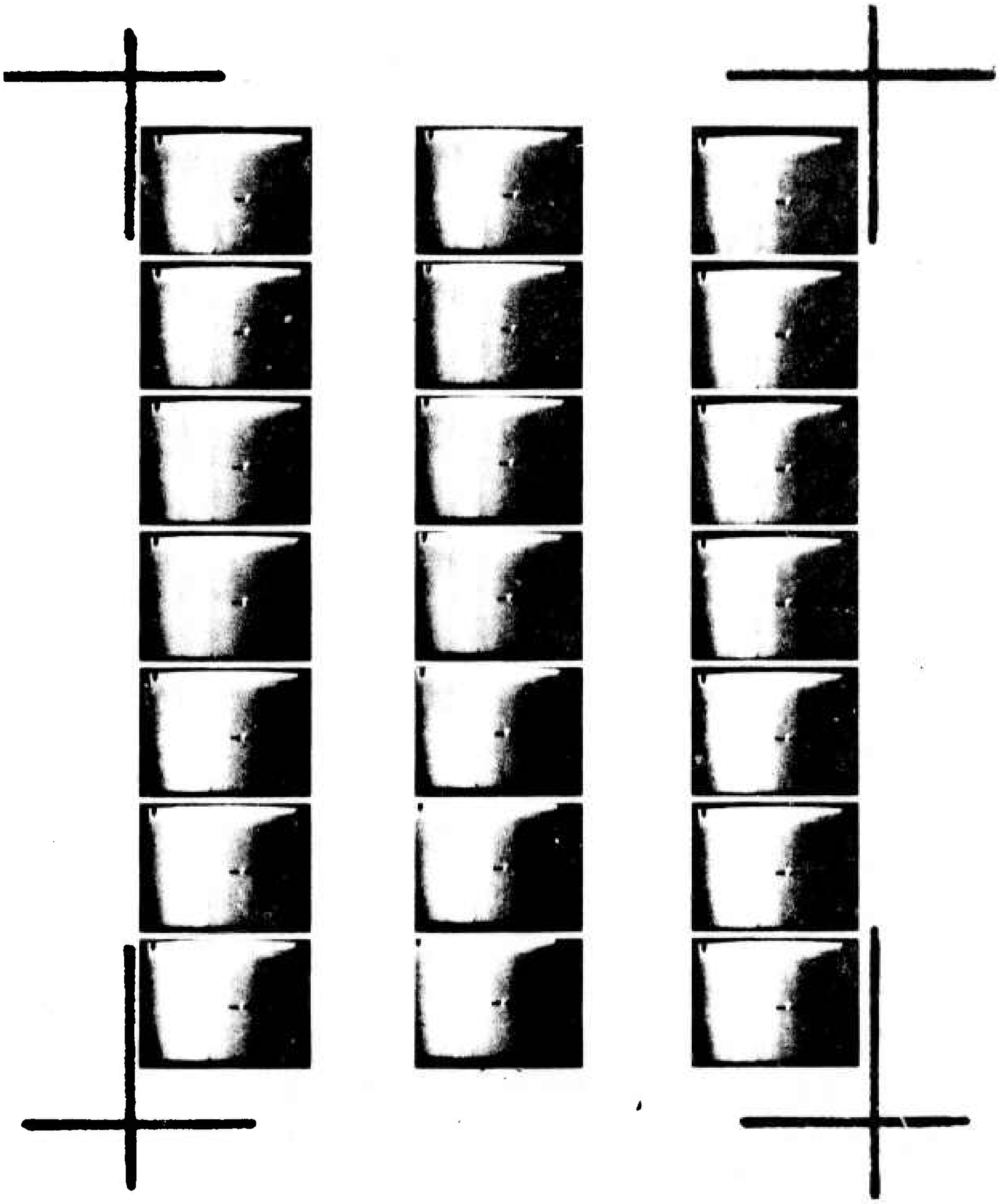
74-0479-PA-31

Run 2; Frames 64 to 84



74-0479-PA-32

Run 2; Frames 85 to 105



74-0479-PA-33

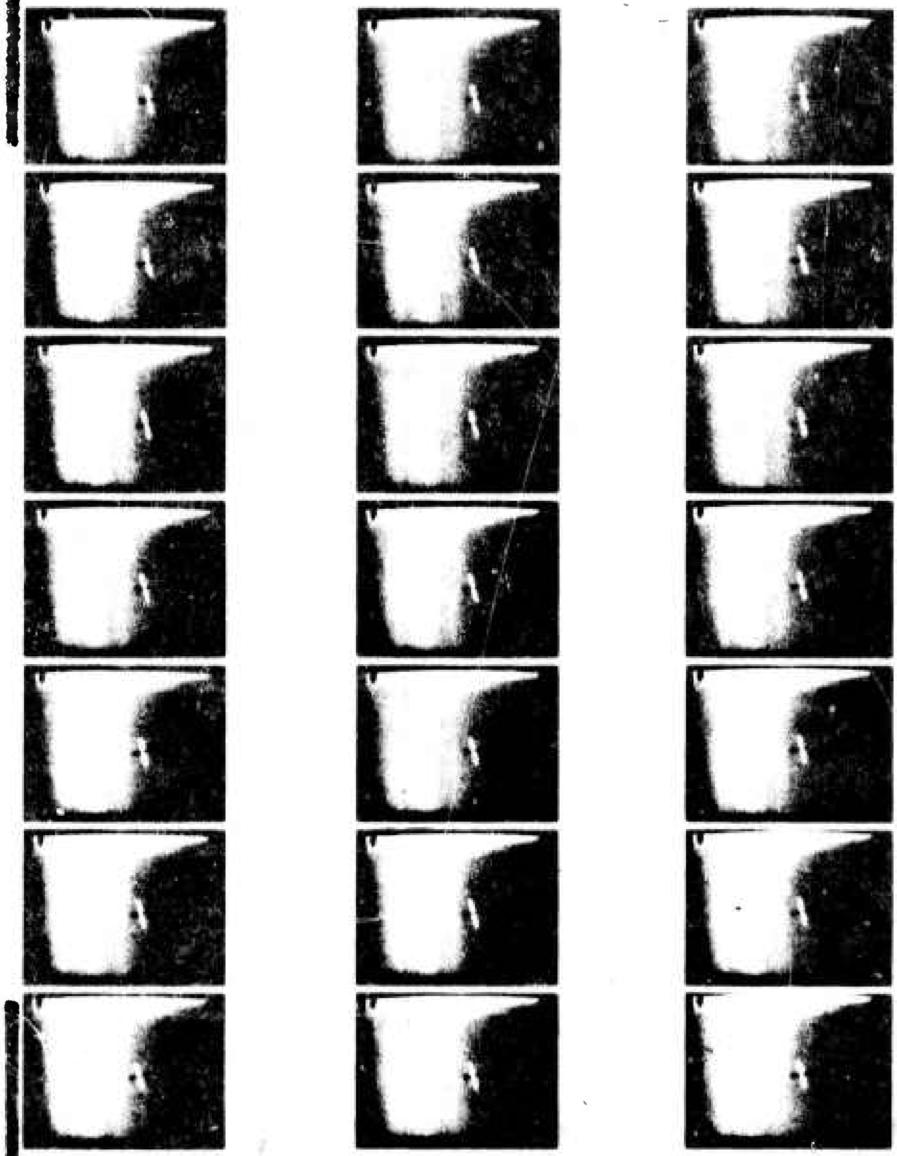
Run 2; Frames 106 to 126

Data Run No. 3

TV Sensor

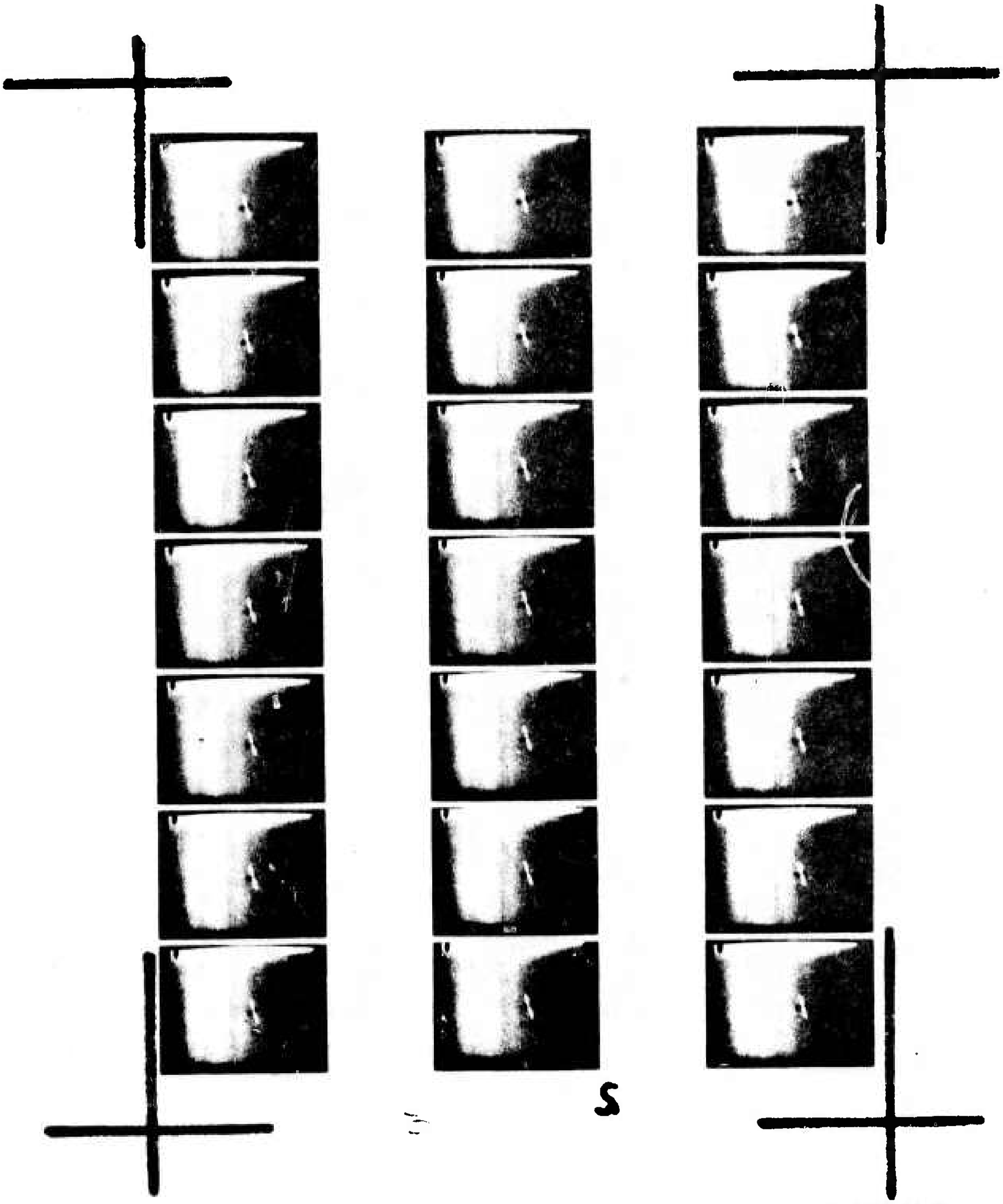
Aircraft Target

Changing Aspect - Sky Background



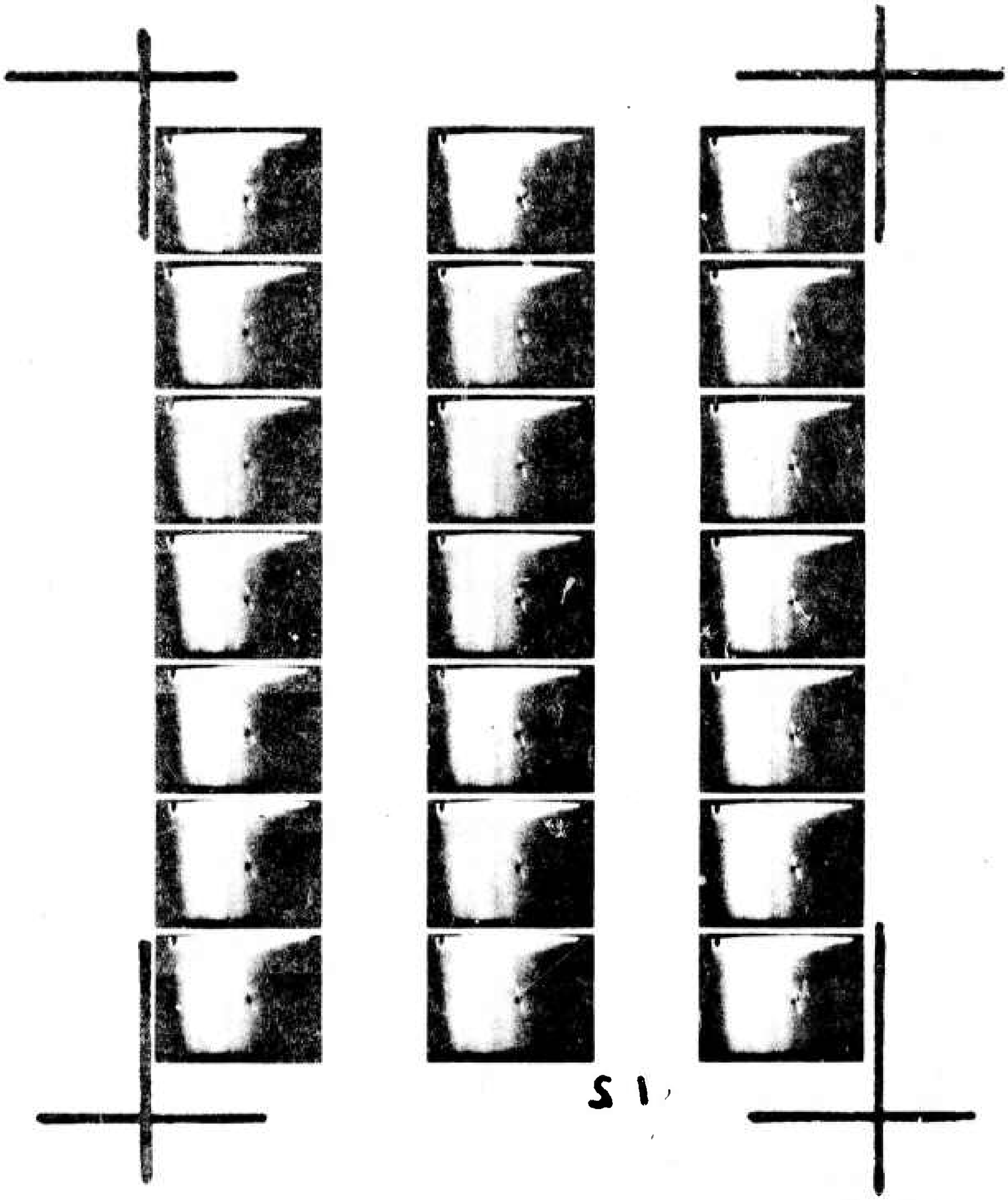
74-0479-PA-34

Run 3; Frames 1 to 21



74-0479-PA-35

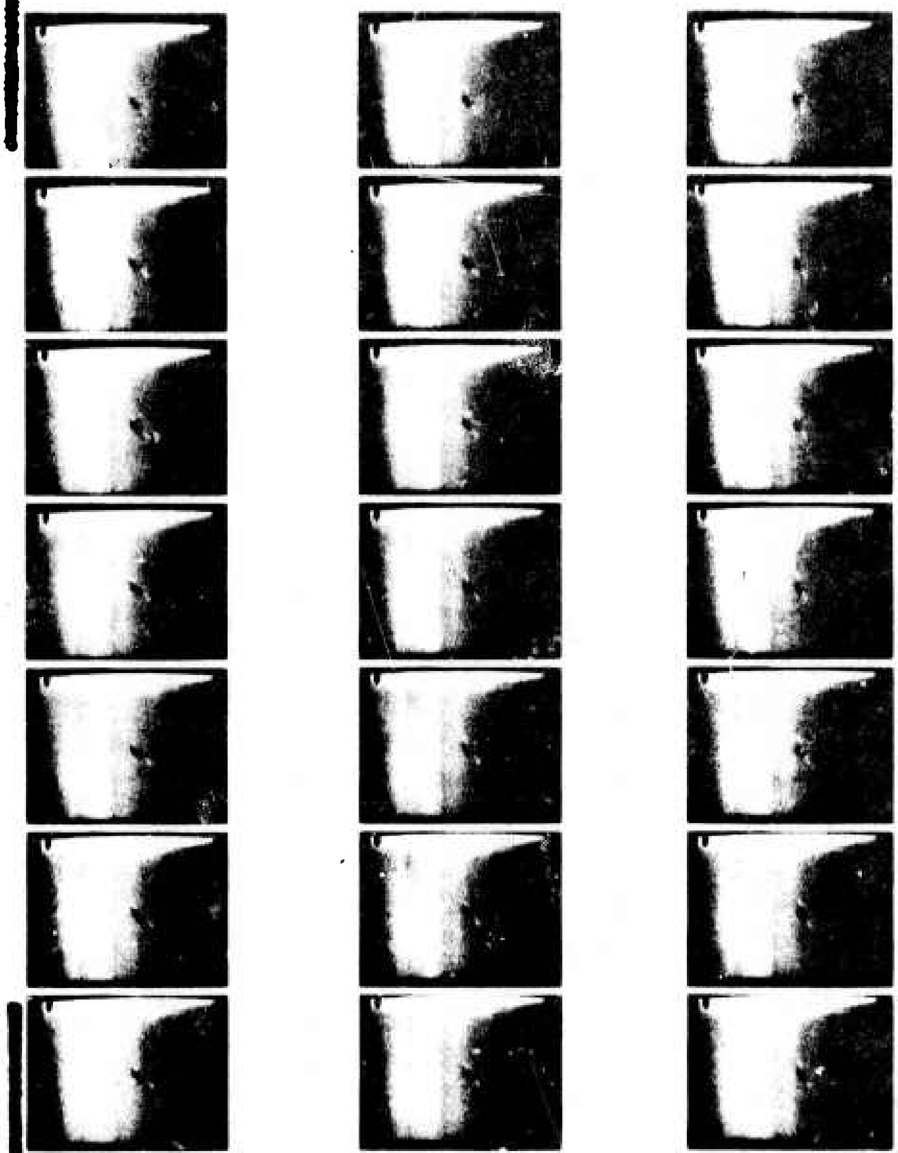
Run 3; Frames 22 to 42



S1

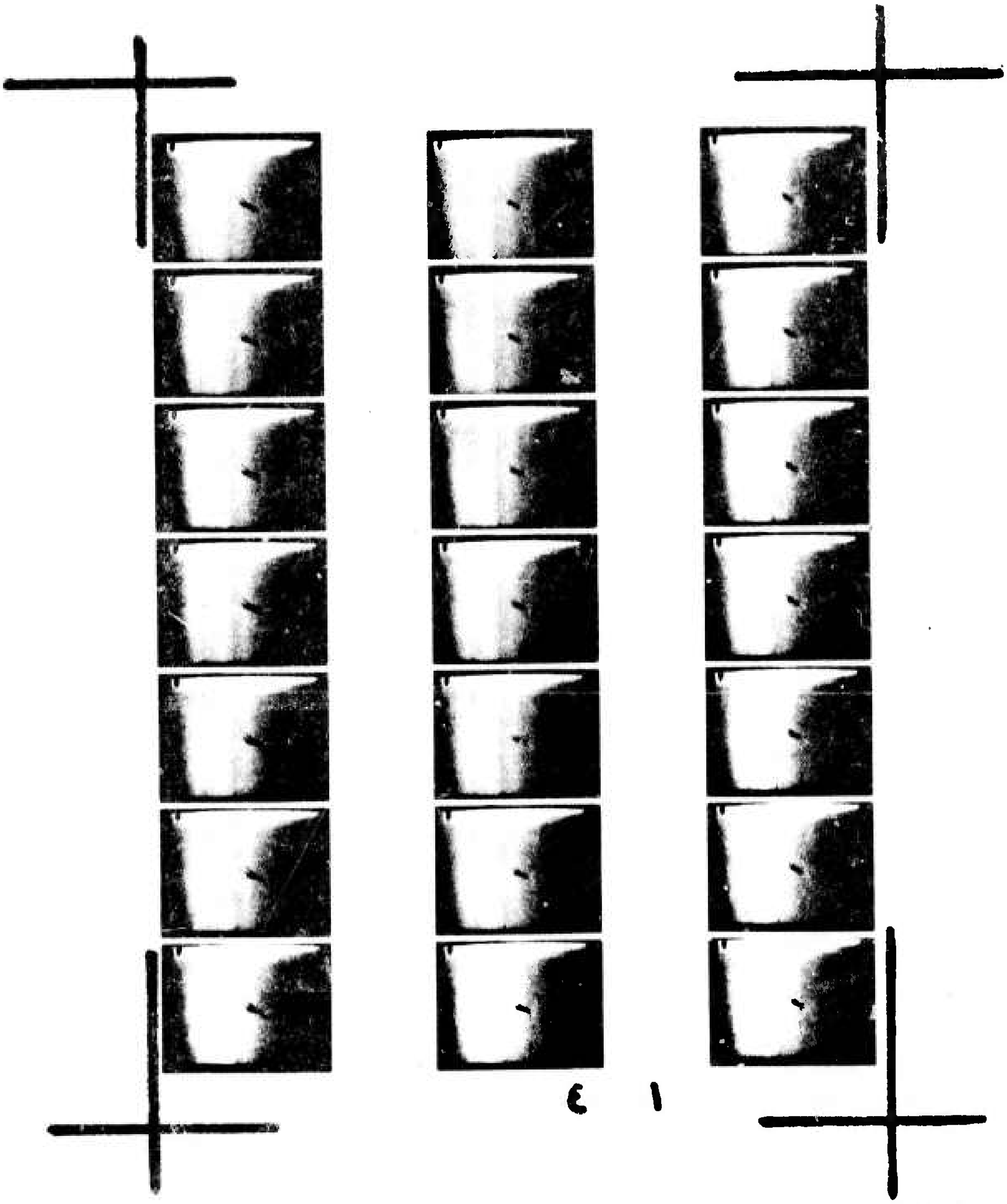
74-0479-PA-36

Run 3; Frames 43 to 63



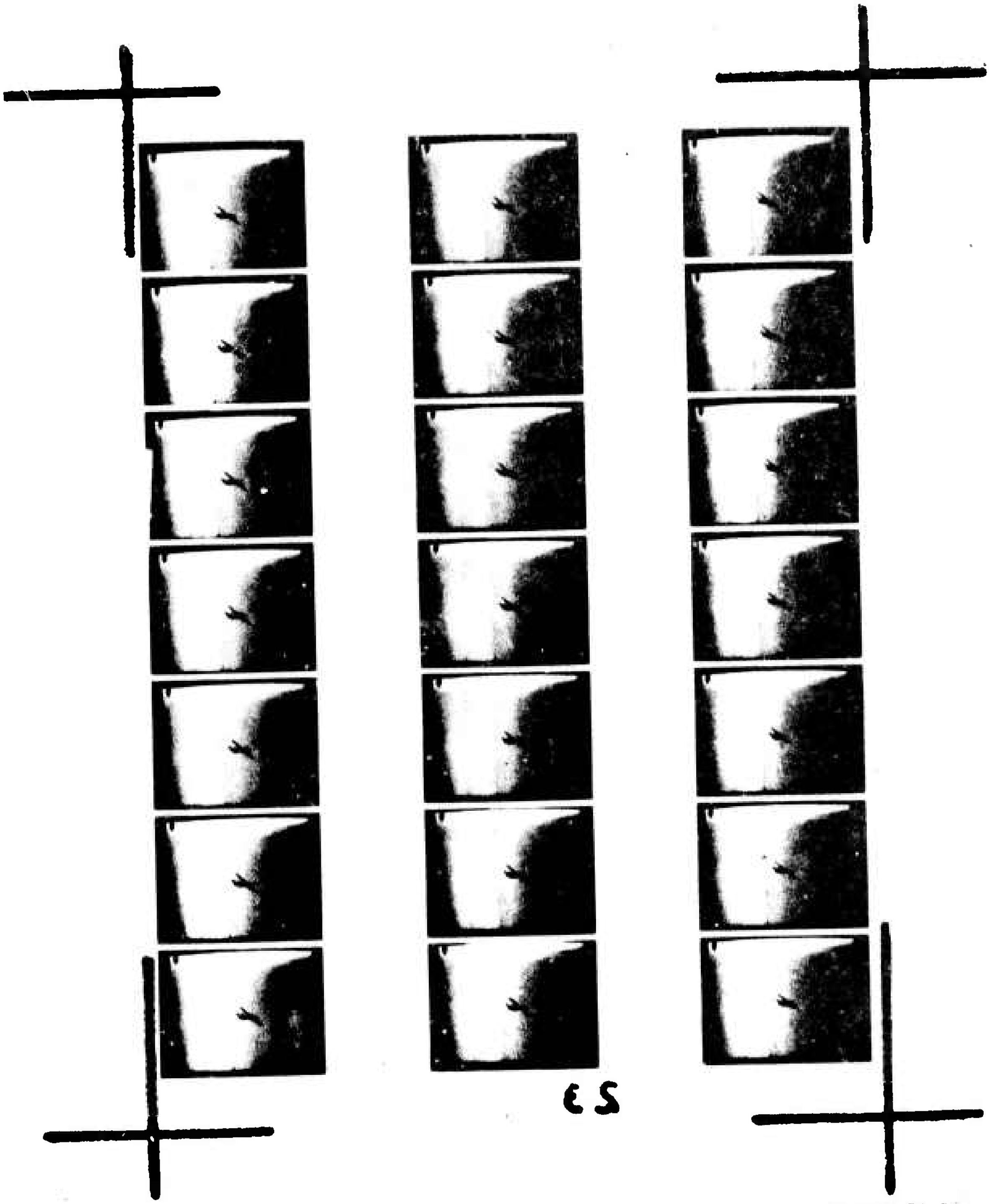
74-0479-PA-37

Run 3; Frames 64 to 84



74-0479-PA-38

Run 3; Frames 85 to 106



ES

74-0479-PA-39

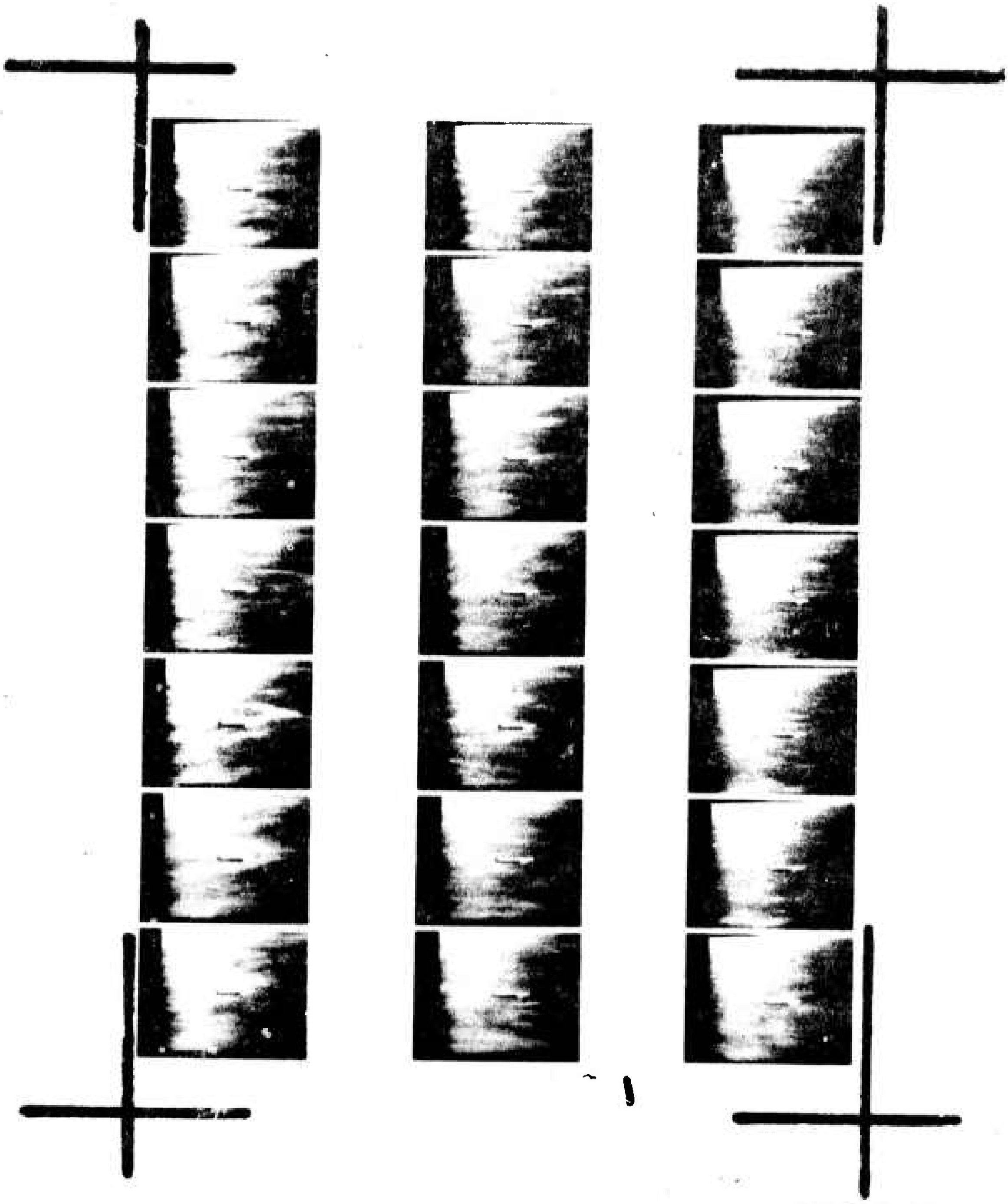
Run 3; Frames 106 to 126

Data Run No. 4

TV Sensor

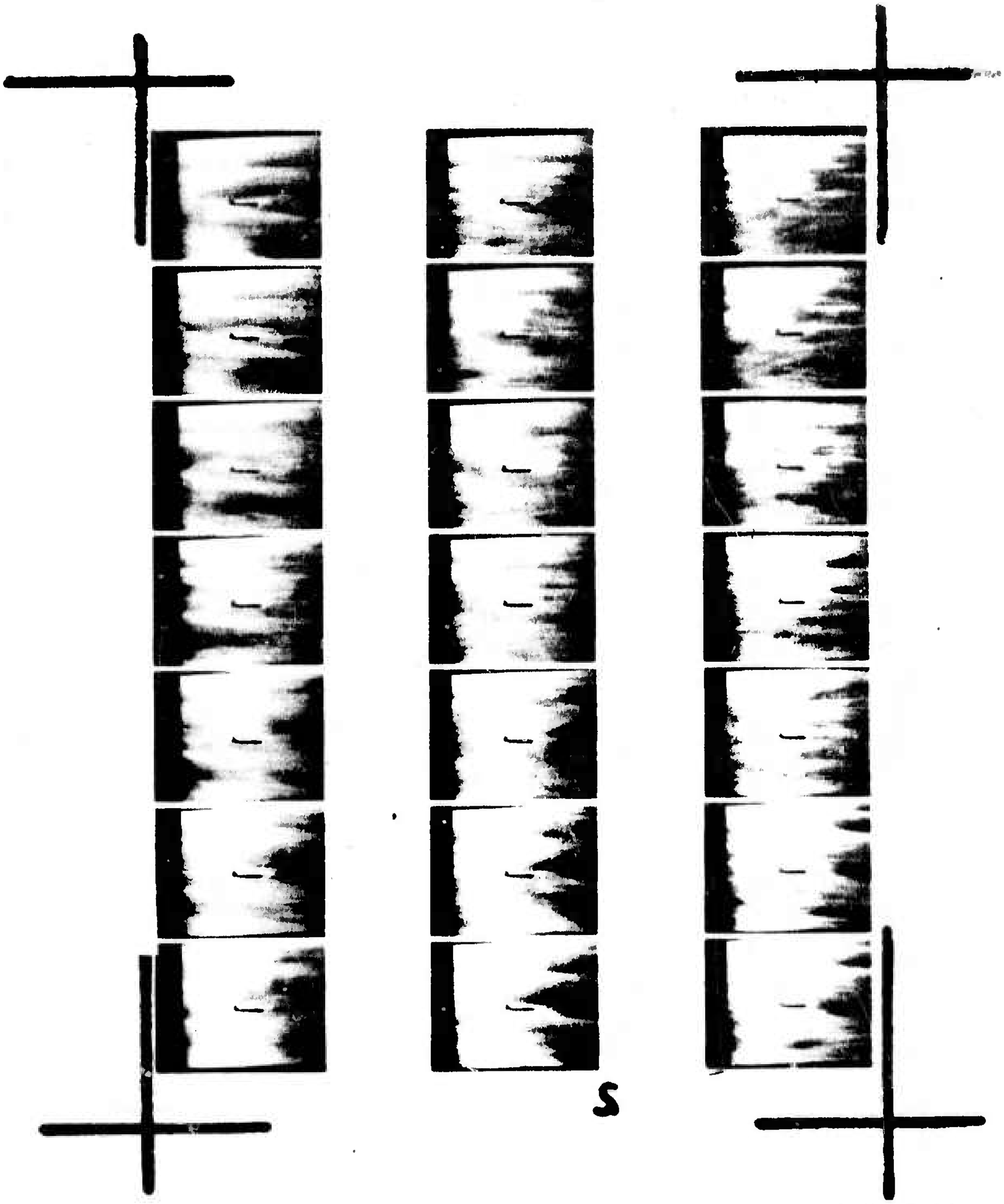
Aircraft Target

Level Flight - Mountainside Background



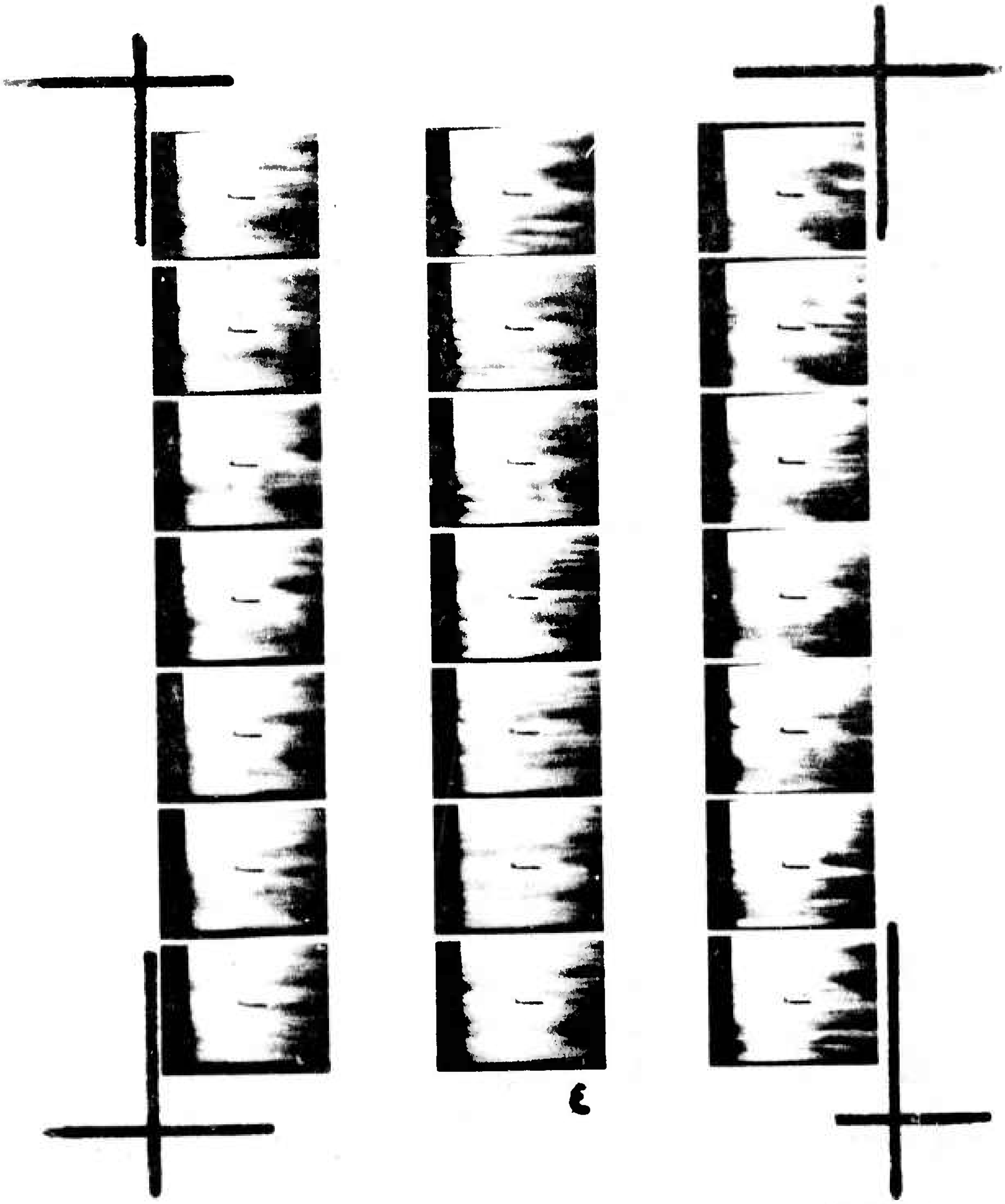
74-0479-PA-40

Run 4; Frames 1 to 21



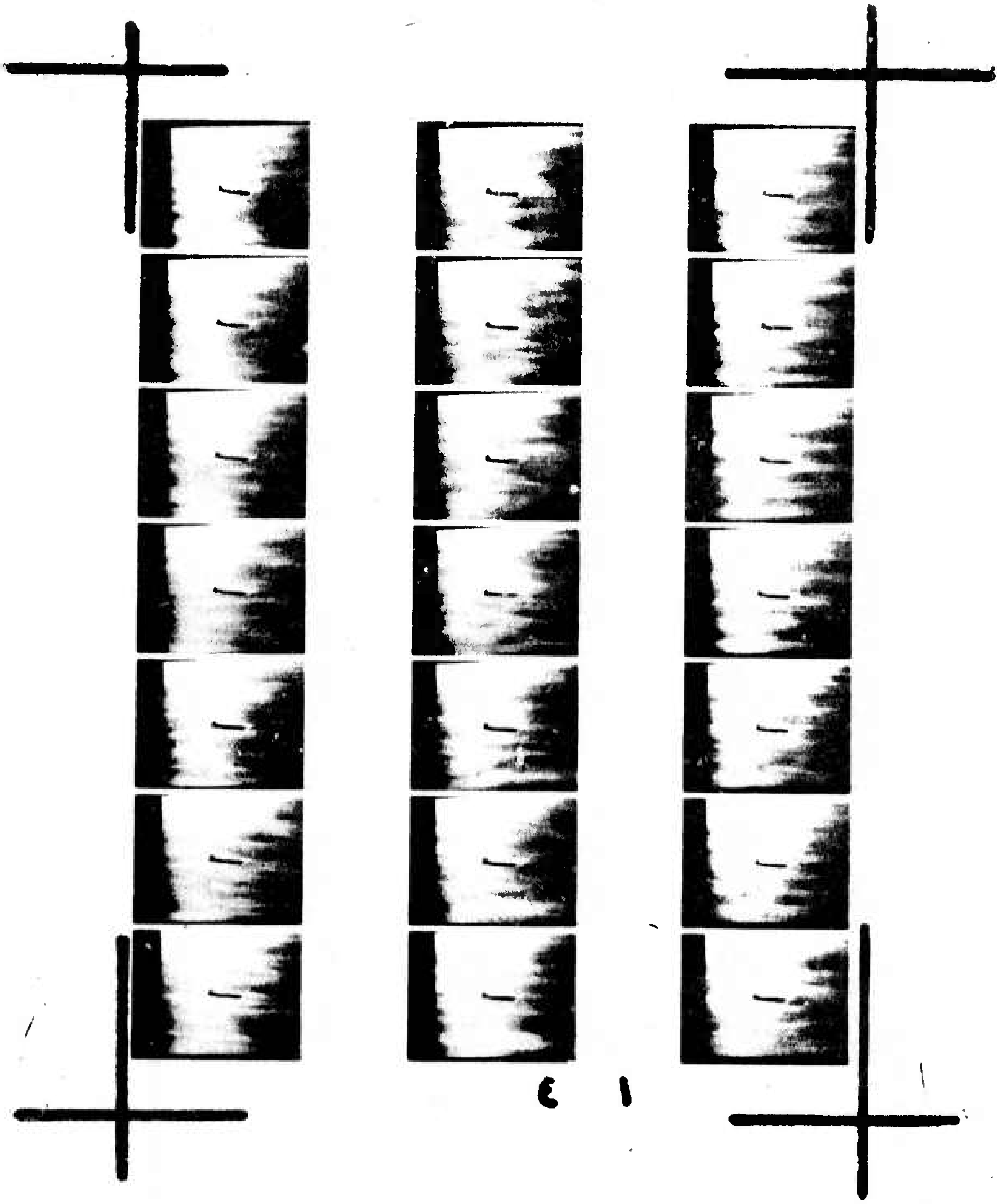
74-0479-PA-41

Run 4; Frames 22 to 42



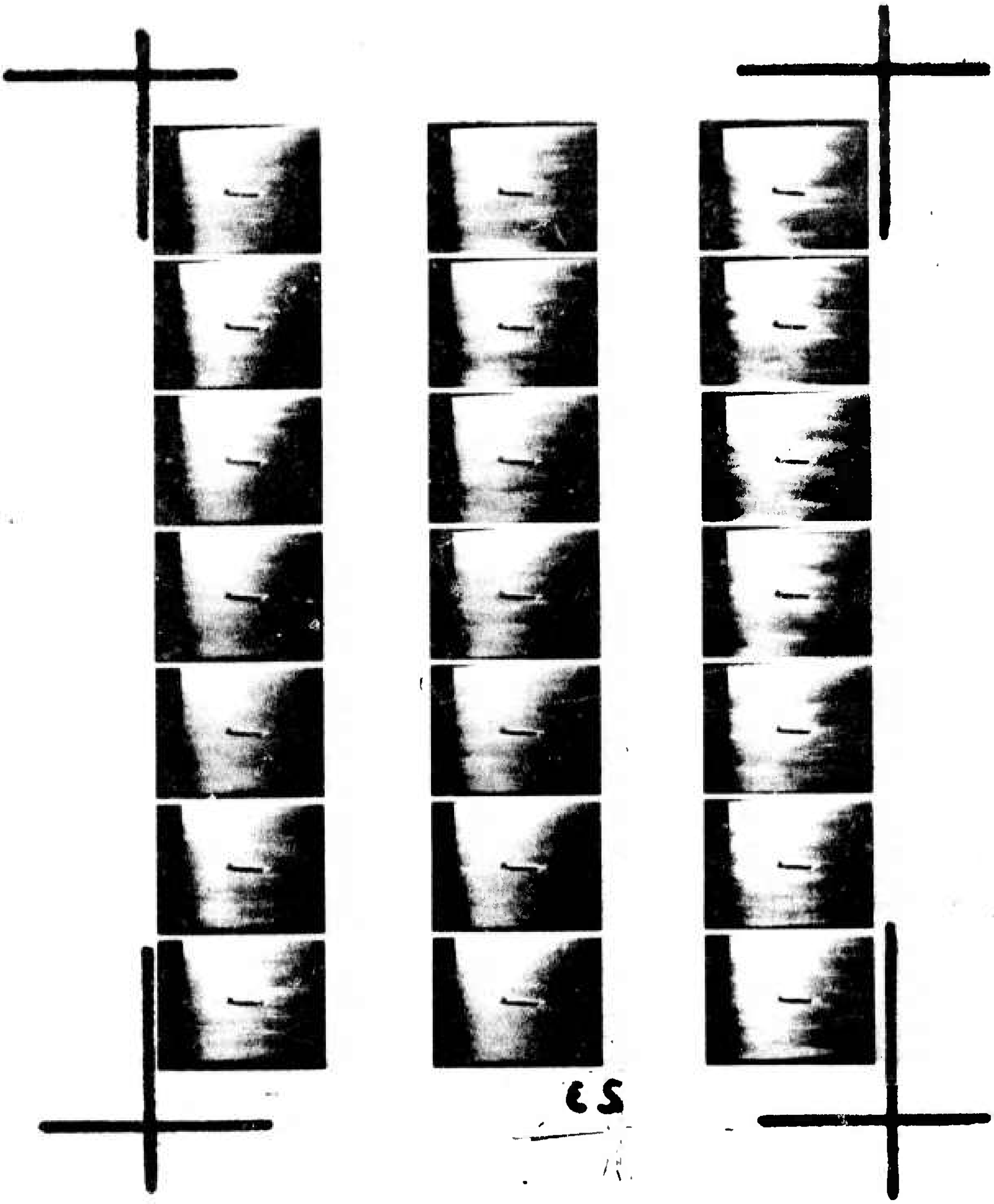
74-0479-PA-42

Run 4; Frames 43 to 63



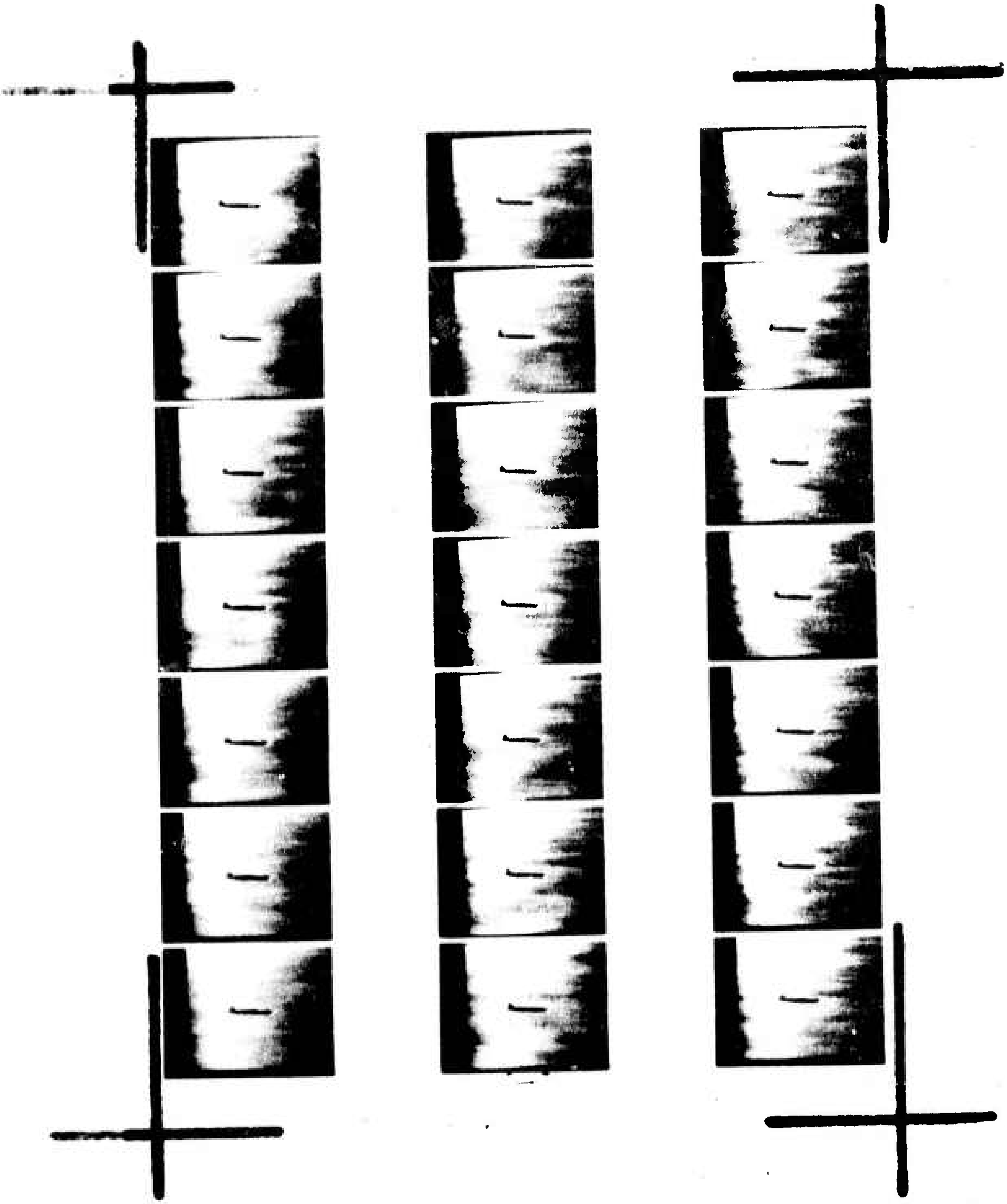
74-0479-PA-43

Run 4; Frames 64 to 84



74-0479-PA-44

Run 4; Frames 85 to 105



74-0479-PA-45

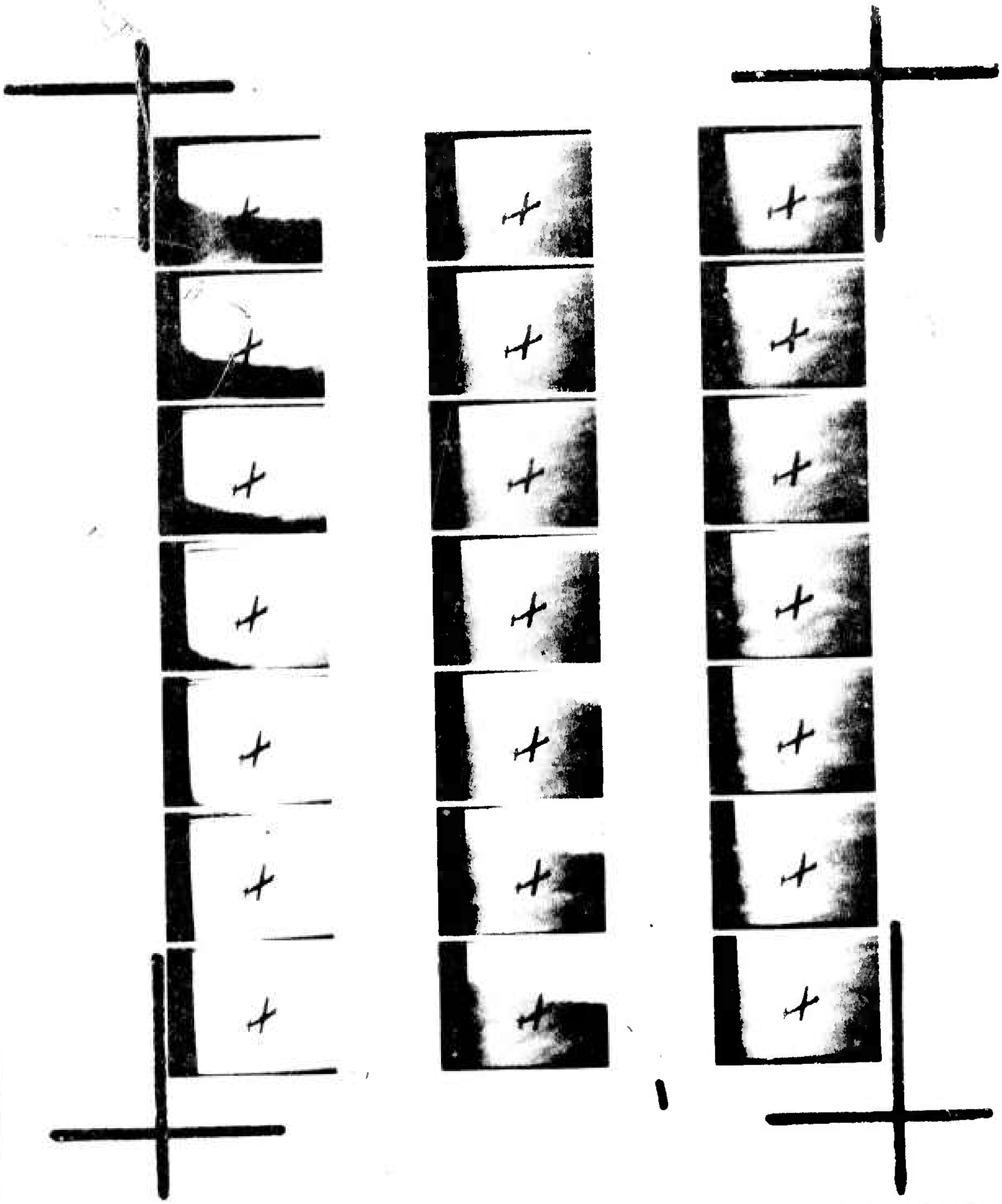
Run 4; Frames 106 to 126

Data Run No. 5

TV Sensor

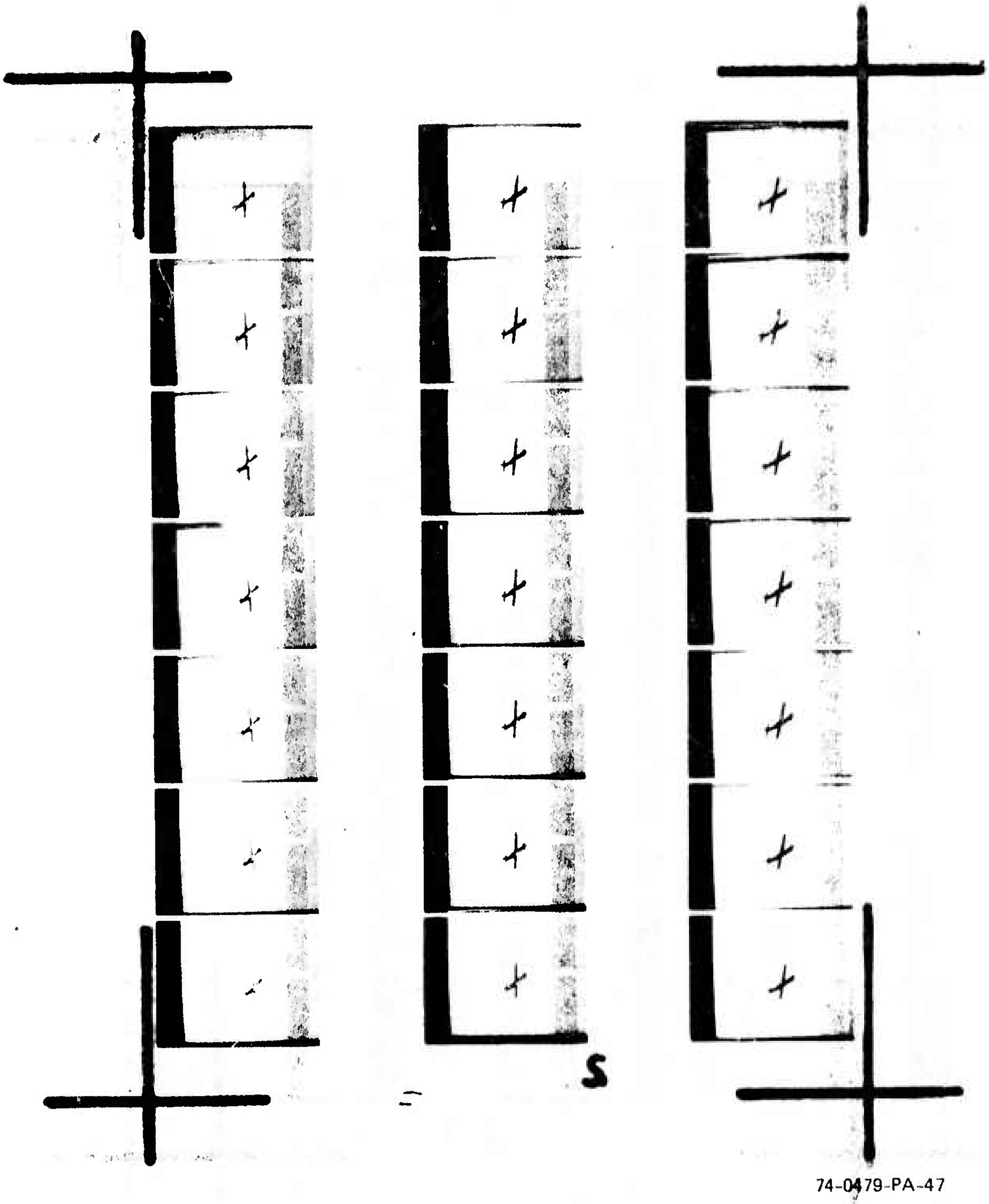
Aircraft Target

Changing Aspect - Crossing Mountain/Sky Horizon

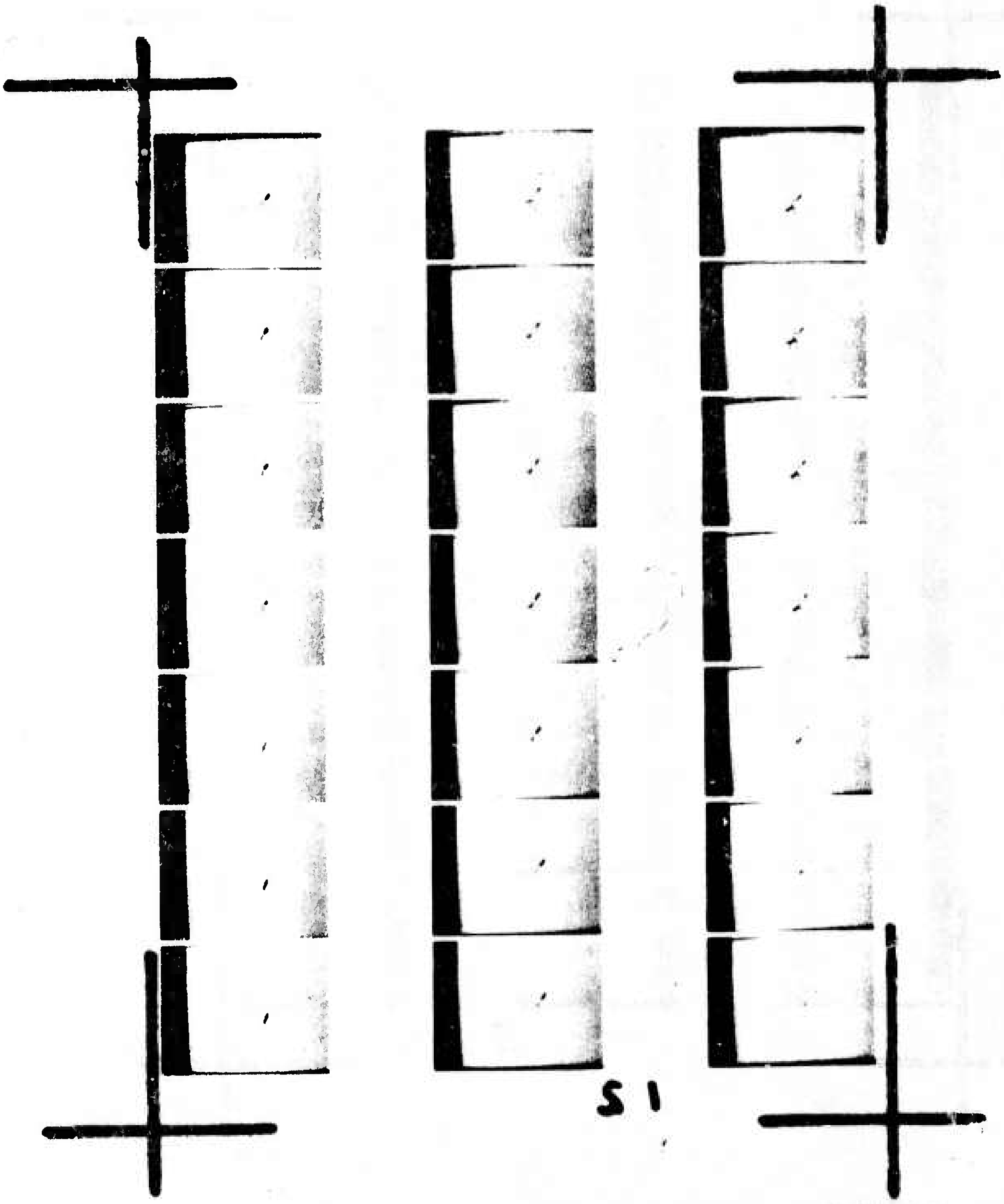


74-0479-PA-46

Run 5; Frames 1 to 21

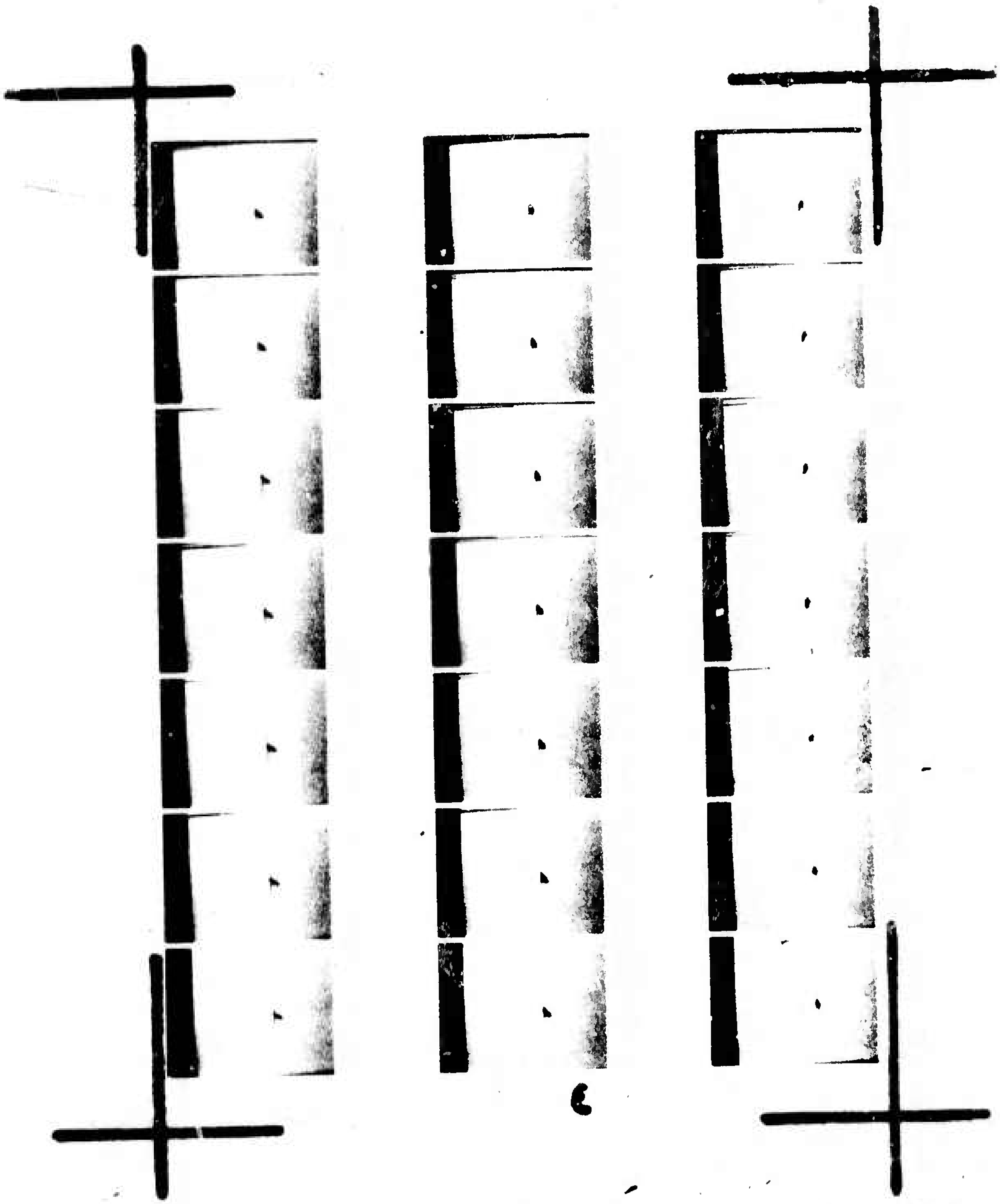


Run 5; Frames 22 to 42

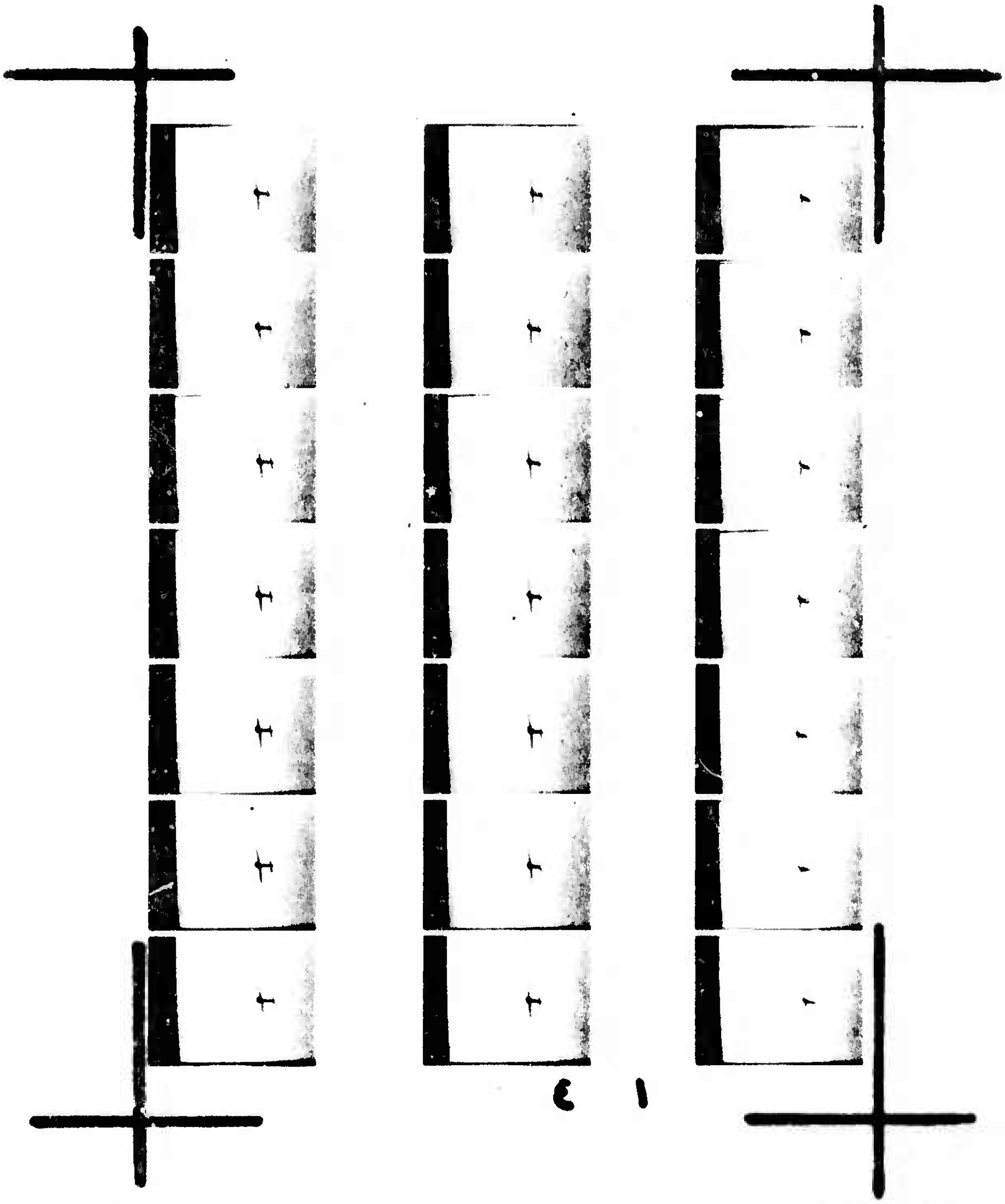


74-0479-PA-48

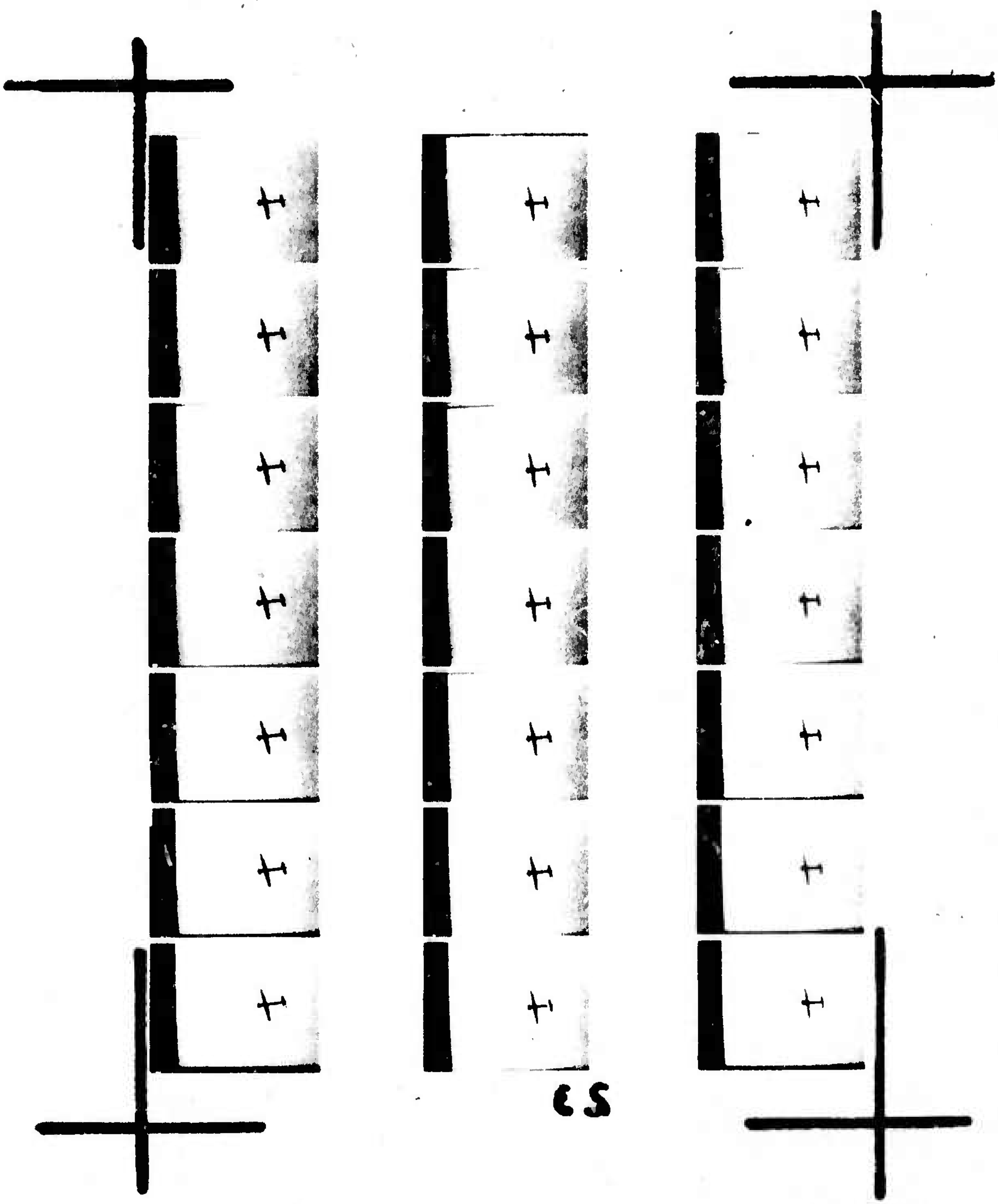
Run 5; Frames 43 to 63



Run 5; Frames 64 to 84



Run 5; Frames 85 to 105



74-0479-PA-51

Run 5; Frames 106 to 126

APPENDIX V

COMPUTER PRINTOUTS

The body of this appendix is composed of copies of the computer printouts obtained during the final production runs of the Computer Simulation Package (CSP) on the CDC 6600. These runs were conducted to evaluate the performance of the selected digital correlation tracker algorithm and to compare its performance with that of edge and centroid tracker algorithms operating on the same target imagery data. The input imagery processed was television and infrared imagery supplied by AFWL. This imagery had been converted to 64 level digital information in a 100 by 100 element picture format for input to the CSP.

Computer runs numbered 80, 82, 84, and 86 used the TV imagery presented in Appendix IV as data runs numbered 2, 3, 4, and 5, respectively. Runs 88 and 90 were conducted using IR imagery of a stationary target with the sensor operating with narrow (run 88) and wide (run 90) fields of view. Runs 92 and 94 used IR imagery of the same aircraft target shown in the TV imagery, again in narrow and wide fields of view respectively.

In run 80, the aircraft wing section was designated as the tracker target, and in run 84 the trackers were assigned to track the tail section. For the remaining runs - numbers 82, 86, 92, and 94 - the trackers tracked the aircraft nose.

Each computer run printout begins with a referencing program title page that identifies the number of referencing operations conducted or the number of pictures processed. This number has a maximum value of one less than the total number of frames of imagery in the input data that are compared to the reference scene to determine where maximum correlation occurs.

Next in the listing are the coordinates of the upper left hand corner of the window in the first frame of data that is selected by the operator as the target. This scene becomes the first reference image. The coordinates are given in the order Y, or horizontal row number, increasing downward, and X, or vertical column number, increasing to the right; they are measured in numbers of picture elements in the 100 by 100 element input imagery.

The tape output option selected is also shown as a 0 for no tape output or as a 1 if an output referenced imagery data tape is desired for input to the tracking program portion of the CSP. Finally, the polarity of the contrast of the selected target relative to its background is indicated as positive (POS) or negative (NEG). Since the threshold processing in the centroid tracker algorithm accepts only signals above a threshold level, the signals are inverted before thresholding when negative target contrast is indicated.

The second page of each printout repeats the starting target coordinates and then presents the location in each scene after the first or reference scene (number 0) where maximum correlation was measured by the referencing program. This table, entitled "Coordinate Error Analysis," lists each frame number (NPIX) after the reference scene plus the X and Y coordinates of the location in the scene where maximum correlation was found. The coordinates of this location are presented as X ERROR and Y ERROR, which define the position of the correlation maximum relative to the original starting coordinates in units of picture elements.

The third table of each computer run printout provides an evaluation of the effective signal-to-noise ratio of the imagery being processed by the referencing program. The computation by which this ratio is derived was described in paragraph 3. 1. 5. 2. The tabulation gives the sample number, each sample consisting of 10 frames of imagery, plus the signal level, noise level, and signal-to-noise ratio averaged over the 10 data frames. The units of measurement in this table are relative to the scale of 64 units of peak-to-peak brightness variation in the initial reference scene. At the end of the

table, the average or resultant signal-to-noise ratio for all of the samples is printed.

The remaining pages of each computer run printout are the outputs from the tracking program portion of the CSP. The tracking program title page gives the run number and then lists the various optional parameters selected for the run. Items listed include the size of the tracking gate selected for the centroid and edge trackers, given in terms of the number of columns in the X dimension and the number of rows in the Y dimension, of picture elements within the gate. Following is the location of the center of the scene given by the number of picture element rows and columns from the upper left hand corner of the image data array.

The frequency of printout of the data from the tracking program is listed next, measured in the number of data frames between printouts. A printout of the data obtained on the last frame of each run is included for each computer run in this appendix. The next line indicates the source of video data to be used. Only unit 1, the data tape supplied from the referencing program, was used for these tracker evaluation runs.

Continuing with the title page listing, the frames of data tape imagery that are processed in the tracking program run are identified next. This is done by indicating the number of frames of data at the beginning of the tape that the user elected to skip plus the number of sequential frames, including an initial reference frame, that he elected to process.

On the next line of the printout the frame rate or frequency at which the input imagery data was recorded is indicated in hertz. This value is later used in computing the spectral power density of the tracking error signal. The amplitude resolution of the input imagery data is then indicated in terms of the number of input binary bits needed to define the scene brightness in each picture element. The maximum number of bits available is 8, corresponding to the 64 levels of input data supplied to the CSP.

Next in the tracking program title page printout is a listing of the selected values of several program parameters. These parameters are described in the Computer Simulation Package User's Manual, where they are defined as follows:

- ICOLPS - A program variable that enables the programmer to vary the effective size of the tracking gate of the correlation tracker. If ICOLPS equals 0, the gate is a 16 by 16 element array of the input imagery data. If ICOLPS equals 1, the input imagery is collapsed, adding groups of 4 contiguous picture elements to create a new data element in the collapsed picture. This effectively increases the gate size so that it corresponds to a 32 by 32 element array in the input picture while maintaining a fixed 16 by 16 element array of data for processing in the digital correlation tracker.
- IOFF - A variable that selects the type of offset of the target scene that the trackers will be expected to detect during the run. When IOFF equals 0, a set of random offsets is used. If IOFF equals 1, offset values are obtained from a transient table.
- SCALOF - A scale factor that determines the peak amplitude of the random offset of the target scene. When IOFF equals 0, offsets in both X and Y will be randomly distributed between ± SCALOF, where the value of SCALOF is no greater than 7 elements. This prevents the target scene from moving outside of the 32 by 32 element picture searched by the tracking gate.
- SFACX - A scale factor for the transient offset selected when IOFF equals 1. The X offset will be SFACX times the value from the transient offset table. SFACX also has a maximum value of ±7.
- SFACY - A scale factor for transient offsets in the Y coordinate direction.

After the tabulation of these program variables, the tracking program title page lists the signal preprocessing and thresholding procedures selected from the various available options in the CSP. For the edge tracker, the input video data is converted to single-bit binary data in a threshold detector that operates at a level selected automatically in the program or preset by the user. A thinning procedure is also available to reduce the width of the target contour data. For the centroid tracker input, the threshold level and the format of the thresholded video data, either single-bit binary or multiple-bit (linear) binary digital, are selectable.

The options chosen are listed on the tracker program title pages. The optional inputs for the digital correlation tracker include the above two formats of thresholded video as well as unthresholded video data. The correlation metric selected from among the four available options in the correlation tracker algorithm is also listed along with the manner and frequency of the correlation reference update during the tracking run.

Finally, the tracking program title page concludes with a listing of the effective gains of the tracker error detectors averaged over the complete run. These gains are ratios of the indicated tracker error to the actual error induced by the offset routine. Values are listed for each of the three tracker algorithms in each of the two tracking coordinates.

After the title page, the next 5 pages of the tracking program printout are reproductions of the 32 by 32 element digital picture matrix at various points in the preprocessing cycle. This is the matrix searched by the tracking gate. The first picture presents the input data from the referencing program converted to 4-bit digital data so that it can be printed out in a single-digit scale with a slash overlay to indicate 10 plus the number printed. The offset selected for this particular frame of data is also indicated on the page with the input data matrix.

The second picture matrix presents the video gradient data array derived from the input imagery and supplied to the edge tracker. The third picture illustrates this data array after processing in a threshold detector. These data are input to the edge tracker processor for derivation of the tracking error signal. The fourth and fifth pictures present the data arrays that are input from the preprocessors to the digital correlation tracker and centroid tracker error-signal detectors.

Following the input picture arrays, the next page of the printout presents a tabulation of tracking errors derived on the last frame of imagery processed during the run. It also presents a readout of the 16 by 16 element reference picture employed in processing this last frame of data in the

digital correlation tracker. The tracker error data tabulated for each of the three tracking algorithms consists of the directly measured errors, XM and YM, and the corrected tracking errors, XC and YC, in each coordinate direction. The measured errors are the coordinates of the location that the tracker indicates to be the true target position relative to the original target position in the data array.

To correct this error information, consideration must be given to the offset in the target position (either random or transient) that was introduced for this frame. This offset is listed below the tracker errors in the order X offset and Y offset. Another parameter that must be considered is the incremental error in target position that was detected by the referencing program. While the referencing program outputs data arrays with the target always in the same position to the nearest data element, fractional position changes are not corrected but are recorded as input incremental errors to the track program. These errors in X and Y are also listed after the tracker errors.

For example, the corrected error in the X coordinate on sample 100 of run 80 for the edge tracker is computed as follows:

Measured X error XM	-0.4088
Less frame X offset	-(-1.0000)
	+0.5912
Less X input incremental error	-(0.1250)
Equals corrected X error XC	+0.4662

All of the numerical values presented in this table of tracking errors are in units of picture elements. At the bottom of the tabulation of tracking errors, the actual values of the correlation metric are listed for a 9-element (3 by 3) array of positions in the data matrix centered about the location where maximum correlation was measured. Maximum correlation is indicated by a minimum value of the metric. Values are listed in this order: upper row left, center, and right columns; middle row left, center, and right columns; and lower row left, center, and right columns.

The next page of the computer printouts provides a summary of the statistical tracking error-signal data. The mean tracking error during the run, the rms tracker jitter after subtraction of drift, and the drift or regression coefficient (beta) are given for each coordinate axis for the three trackers. The radial rms jitter is also listed for each tracker as well as the radial drift distance. All data are evaluated in units of picture elements.

The radial jitter is obtained by computing the square root of the sum of the squares of the rms error in the two coordinate directions. The radial drift is obtained by a similar calculation of the square root of the sum of the squares of the two coordinate regression coefficients, with the resultant multiplied by the number of frames processed in the tracking run.

This statistical data summary is followed by two tables of frame-to-frame tracking error data. The first table presents the measured tracking error data first corrected for tracker gain variation by dividing by the effective gains listed on the tracking program title page. The further corrections to compensate for offset and input incremental error are then added as previously described.

For example, the tracking error in the X coordinate of the centroid tracker on sample 100 of run 80 is computed as:

Measured X axis error, XM	-1.2331
Divided by X axis gain	÷0.97828
	-1.2604
Less X axis offset	-(-1.000)
	-0.2604
Less X axis input incremental error	-(0.1250)
Corrected X axis error	-0.3854

This is the last value listed in the table under centroid X axis tracking errors. The frame-to-frame errors are listed in order reading from left to right for each set of 10 frames. Data values are given in each coordinate axis for the three trackers.

The second table presents the same frame-to-frame tracking error data after filtering by the expected tracker servo-loop response function.

Finally, the last 12 pages of each computer run printout present the computed power spectral density of the filtered error signals in tabular and graphical form for both coordinate axes of the three trackers. The amplitude of the power spectral density is given in terms of units squared per hertz, where the units are the tracker error signal amplitude in picture elements.

CDC 6600 CSP Printout I

Reference Program: Processing of TV data, run no. 2

Tracking Program: Run no. 80 using above referenced data

```
IGITAL CORRELATION TRACKER - REFERENCE PROGRAM

PROCESS125 PICTURES
SEARCH WINDOW IS 16 X 16
STARTING TARGET COORDINATES ARE (41,52)
TAPE OUTPUT OPTION IS 1

CONTRAST ......POS
```

COORDINATE ERROR ANALYSIS

STARTING COORDINATES * X= 52.00
Y= 41.00

****

NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR
1	0.00	0.00	2	2.44	-5.50	3	3.06	-3.38
4	5.00	-2.69	5	2.88	-3.31	6	1.69	-2.81
7	2.38	-4.06	8	-.06	-1.69	9	-1.63	-.44
10	1.13	-1.06	11	.88	-1.75	12	-1.75	-1.19
13	-1.19	-2.50	14	3.25	-.69	15	-.69	-1.63
16	2.81	-2.81	17	3.19	-.50	18	-1.13	-1.38
19	1.31	-2.06	20	-1.19	-.94	21	1.44	-2.31
22	3.25	-2.50	23	2.31	-3.06	24	4.50	-2.19
25	4.56	-2.94	26	3.31	-1.25	27	2.75	-2.44
28	1.50	.31	29	-.50	-2.31	30	2.00	-.88
31	1.44	-2.44	32	1.25	-2.13	33	2.50	-.88
34	2.69	.06	35	2.50	-1.31	36	1.06	-.75
37	3.00	-1.25	38	.44	-2.56	39	2.56	-2.56
40	4.00	-1.63	41	4.13	-2.06	42	4.06	-1.88
43	2.31	-1.94	44	4.00	-3.94	45	3.06	-3.50
46	3.94	-1.31	47	3.75	-2.50	48	3.31	-1.06
49	2.75	-2.44	50	1.63	-2.38	51	4.69	-1.13
52	.50	-.94	53	2.81	-2.25	54	3.75	-1.44
55	2.63	-4.25	56	2.31	-2.88	57	3.44	-2.44
58	2.13	[illegible]	59	2.00	-.94	60	-.13	-3.06
61	5.13	-1.63	62	2.88	-1.81	63	1.81	-.44
64	1.56	-2.69	65	3.31	-2.06	66	3.50	-2.44
67	2.25	-3.63	68	3.38	-2.81	69	4.81	-1.81
70	2.75	-2.00	71	3.25	-.44	72	3.56	-3.00
73	4.31	-3.56	74	5.19	-3.50	75	5.75	-1.38
76	6.25	-3.19	77	7.38	-2.88	78	5.19	-.19
79	4.38	-3.00	80	3.50	-1.75	81	6.63	-1.63
82	3.81	-2.81	83	5.13	-1.50	84	3.25	-3.75
85	2.44	-3.06	86	4.38	-4.63	87	5.69	-3.06
88	4.50	-2.13	89	5.88	-1.81	90	3.56	-3.00
91	3.25	-1.50	92	4.13	-3.00	93	2.44	-2.44
94	3.75	-2.50	95	3.38	-1.94	96	4.50	-1.75
97	3.38	-2.31	98	4.63	-1.44	99	5.56	1.81

SIGNAL/NOISE DETERMINATION

SAMPLE	SIGNAL LEVEL	NOISE LEVEL	S/N
1	11.32	2.19	5.17
2	11.59	2.04	5.67
3	11.28	2.52	4.49
4	11.48	2.53	4.54
5	11.80	1.88	6.28
6	11.75	2.02	5.82
7	11.51	2.29	5.03
8	11.59	2.13	3.44
9	11.86	1.91	6.20
10	11.79	2.18	5.41
11	11.77	2.22	5.30
12	11.74	2.23	5.27

RESULTANT SIGNAL/NOISE = 5.385

TRACKING RUN NO. 80

X DIMENSION = 16   Y DIMENSION = 16
X CENTER = 32   Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT 1
0 FRAMES SKIPPED, 101 FRAMES PROCESSED
FREQUENCY = 30.00
5 INPUT BITS USED
ICOLPS = 0   IOFF = 0
SCALOF = 4.00   SFACX = 5.00   SFACY = 5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT 10 FRAMES(SKIP)
LINEAR PROCESSING ABOVE THRESHOLD OF - 20 FOR CENTROID TRACKER

CENTROID - X AXIS GAIN = .97828

CENTROID - Y AXIS GAIN = .76256

DIG CORR - X AXIS GAIN = 1.00000

DIG CORR - Y AXIS GAIN = 1.00000

EDGE - X AXIS GAIN = .17534

EDGE - Y AXIS GAIN = .89056

SAMPLE NO.100   RUN NO. 80

INPUT PICTURE (X OFFSET = -1, Y OFFSET = 3)

INPUT DATA DIVIDED BY 2

5	5	5	5	5	6	8	6	5	5	8	6	8	8	8	8	8	8	9	8	6	9	9	9	9	8	8	8	9	9	9	9
5	5	4	5	6	6	6	6	5	6	8	6	6	8	6	8	6	8	8	8	6	8	9	9	9	8	8	9	9	9	9	9
4	5	4	6	6	5	6	6	5	6	8	6	6	6	6	6	8	6	8	8	8	8	8	9	9	8	8	9	9	9	B	9
5	5	4	6	6	6	6	6	6	8	6	6	6	6	6	6	8	6	8	8	6	8	8	8	9	9	8	9	9	9	9	9
5	5	5	5	5	5	8	6	6	8	8	6	8	8	6	8	8	6	8	8	8	8	8	8	9	8	8	9	8	8	9	9
5	5	5	5	5	5	6	6	6	8	8	6	8	8	6	8	8	6	8	8	6	8	8	8	8	8	8	8	8	8	8	9
5	5	5	5	6	6	5	6	6	8	8	8	8	8	8	8	8	6	8	8	8	8	8	6	8	8	8	8	8	8	8	8
5	6	5	5	6	6	5	5	6	6	6	6	8	8	6	8	8	6	8	8	8	8	9	8	8	9	8	8	8	8	9	9
5	5	5	5	6	5	6	6	5	8	6	6	8	8	8	8	8	6	8	8	8	8	8	8	8	9	8	8	8	8	9	9
5	5	5	6	5	6	6	6	6	8	8	8	9	9	9	9	8	6	8	8	6	8	8	6	9	8	9	8	8	8	9	9
5	5	5	6	6	6	8	6	8	8	9	I	8	Z	I	B	9	8	8	8	8	8	8	6	8	9	6	8	8	8	9	9
5	5	5	6	6	6	8	8	8	9	Z	Z	K	K	K	Z	Z	9	8	8	8	8	8	6	8	8	8	8	8	9	9	9
4	5	5	5	6	5	8	8	8	B	Z	K	B	B	K	K	Z	B	9	8	8	8	8	8	8	8	8	8	8	9	9	9
4	4	5	5	5	5	6	6	8	B	Z	K	B	B	B	B	K	Z	B	8	6	8	8	6	8	8	8	8	9	9	9	B
4	4	4	5	4	5	5	6	6	B	Z	K	B	B	B	B	K	I	B	8	6	6	8	6	8	6	8	8	8	8	9	9
1	1	1	1	1	2	3	3	4	8	I	K	B	B	B	B	K	2	9	5	4	5	4	4	5	5	4	5	6	5	6	6
.	.	.	.	.	.	.	.	.	1	6	Z	B	B	B	B	B	Z	9	3	.	.	.	.	.	.	.	.	1	.	1	2
.	.	.	.	.	.	.	.	.	.	1	9	Z	B	B	B	B	Z	9	1	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	2	B	K	B	B	B	K	Z	1	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	8	Z	B	B	B	Z	I	3	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	1	8	Z	K	K	K	Z	B	5	2	.	.	.	.	.	1	2	3	4	5	4
1	3	2	4	4	3	4	4	4	4	5	5	8	B	I	2	2	B	9	8	5	5	6	6	6	5	6	6	6	6	8	8
4	5	4	5	5	5	6	6	5	6	6	6	8	8	8	9	9	8	8	8	8	8	8	8	8	8	8	6	8	8	9	B
5	6	5	5	6	6	6	8	6	6	6	6	8	8	6	8	8	6	8	9	9	9	8	6	8	8	8	9	9	9	9	B
5	5	5	6	6	6	6	6	6	8	8	6	8	8	8	8	8	6	8	9	8	9	9	8	9	9	9	9	9	9	B	B
6	6	5	5	6	6	6	6	6	8	6	8	8	8	6	8	8	8	8	8	8	9	8	8	9	9	8	9	9	9	B	B
6	5	5	6	6	6	6	6	6	8	8	6	6	8	8	8	8	8	8	8	8	9	9	8	9	9	9	9	9	9	B	9
6	5	5	6	8	6	5	6	6	6	8	8	6	8	8	6	8	8	8	8	8	9	9	8	9	9	9	9	9	9	B	9
5	5	5	6	6	6	8	8	6	6	8	6	6	8	8	9	8	8	8	8	8	9	9	8	9	9	9	9	9	9	9	9
6	6	5	6	6	6	8	6	6	6	6	6	8	8	8	8	9	8	9	8	8	8	9	9	9	9	9	9	B	9	9	B
6	6	5	6	6	6	6	6	6	8	6	6	8	8	8	9	9	8	8	8	8	9	8	8	9	9	9	9	9	9	9	B
6	6	5	6	6	6	6	8	8	8	6	6	6	6	6	8	9	8	8	8	8	8	9	8	9	9	9	9	9	9	B	B

SAMPLE NO.100 RUN NO. d0

VIDEO GRADIENTS

INPUT DATA DIVIDED BY 2

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. 1 . 1 . 2 1 2 1 3 2 1 2 2 2 2 2 1 . 2 4 . . . 1 . 1 1 . . . .
1 1 2 . . 1 . 2 1 3 2 . 2 2 2 . . 2 . 2 2 . . . 1 . 1 . . . . .
1 1 2 . . 1 . . 2 . 2 . . . . 2 3 3 . 2 2 . . 1 . . . . . 1 . .
. 1 1 . . 2 2 . 2 1 2 2 3 2 1 1 2 3 . 2 2 . . 1 . . . . . 1 . .
. . . . . 3 1 . 2 . 2 2 . 2 2 . 2 2 . 2 2 . . 1 1 . 1 . . . 1 .
. . . . . . 1 . 2 . 2 1 . 1 2 . 2 2 . 1 2 . 2 1 . . . . . . . .
1 1 . . . . . . 1 2 2 1 . 1 2 . 2 2 . . . . 2 2 . 1 . . . 1 1 .
1 1 . . . . . . 2 1 . 2 . 2 1 . 2 2 . . . 1 1 . . 1 . . . 1 . .
. . 1 . . . . 1 3 1 2 3 2 1 1 1 2 2 . 1 1 . 1 2 . . . . . 1 . .
. . 1 . . 2 1 1 2 1 4 5 5 4 3 2 2 1 . 2 2 . 2 3 . 2 1 . . 1 . .
. . 1 . . 2 1 1 1 3 4 3 2 3 4 4 3 1 . . . . 2 2 1 2 2 . . 1 . .
1 . 1 . . 3 . . 2 4 2 2 1 1 1 3 4 2 1 . . . 2 2 . . . . 1 . . .
1 . . . . 3 2 2 2 4 2 1 . 1 1 2 4 2 1 2 1 . 2 2 . . . . . . . .
. . 1 1 1 1 1 2 5 4 2 1 . . . 1 4 2 2 3 2 2 2 2 1 1 . . . . 1 .
4 5 5 5 4 4 4 4 7 5 3 2 . . . 1 4 3 5 4 3 4 5 4 3 4 5 4 4 4 4 .
2 2 2 2 2 4 5 5 9 8 8 3 . . . 1 3 5 8 6 7 7 6 7 7 7 7 8 8 8 7 .
. . . . . . . . 1 6 2 6 2 . . . 2 6 1 3 . . . . . . . 1 1 1 2 .
. . . . . . . . . 1 9 2 6 1 . . 2 5 3 2 . . . . . . . . . . . .
. . . . . . . . . . 2 3 8 2 . . 2 4 3 4 . . . . . . . . . . . .
. . . . . . . . . . 1 1 6 4 1 1 2 4 9 6 2 . . . . 1 2 4 6 7 7 .
3 4 5 6 6 5 6 6 6 7 7 8 4 3 3 2 4 3 5 6 7 9 9 9 8 8 7 6 4 4 5 .
4 3 3 1 2 3 3 3 2 2 1 4 2 3 5 5 5 2 1 3 4 4 3 3 4 4 3 3 3 3 2 .
2 1 1 1 1 1 2 2 1 . . 2 . 2 2 1 2 2 . . . . 2 2 . . 1 1 . 1 . .
. 1 . . . . 1 1 2 2 1 2 . 1 2 . 2 3 . . . . 2 2 . . . . . 1 . .
. 1 1 . . . . . 3 2 . 1 . 1 2 . 2 2 . 1 1 . . 1 . . . . . . . .
. . 1 1 . . . . 3 1 . 2 2 1 1 . . . . . 1 . . . . . . . . 1 . .
. . 1 2 2 . . . 2 1 2 2 2 . . . . . . . . . . . . . . . . 1 1 .
. . 1 1 1 2 3 2 . 2 2 1 2 . . . . . . . 1 . 1 . . . . . . 1 . .
1 1 1 . . 2 1 1 . 1 2 2 1 . 1 . 1 1 . . 1 1 . . . . . . 1 . . .
. 1 . . . 1 1 . 1 1 . 3 . . 1 1 1 . . . 1 . . . . . . . . . 1 .
. 1 1 . . . 1 2 1 2 . 1 2 2 2 1 1 . . . 1 . . 1 . . . . . . 1 .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO.100 RUN NO. 80

EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . 1 1 . . . . . . . . . . . . . . . . . . .
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SAMPLE NO.100 RUN NO. 80

OCT TRACKER INPUT DATA

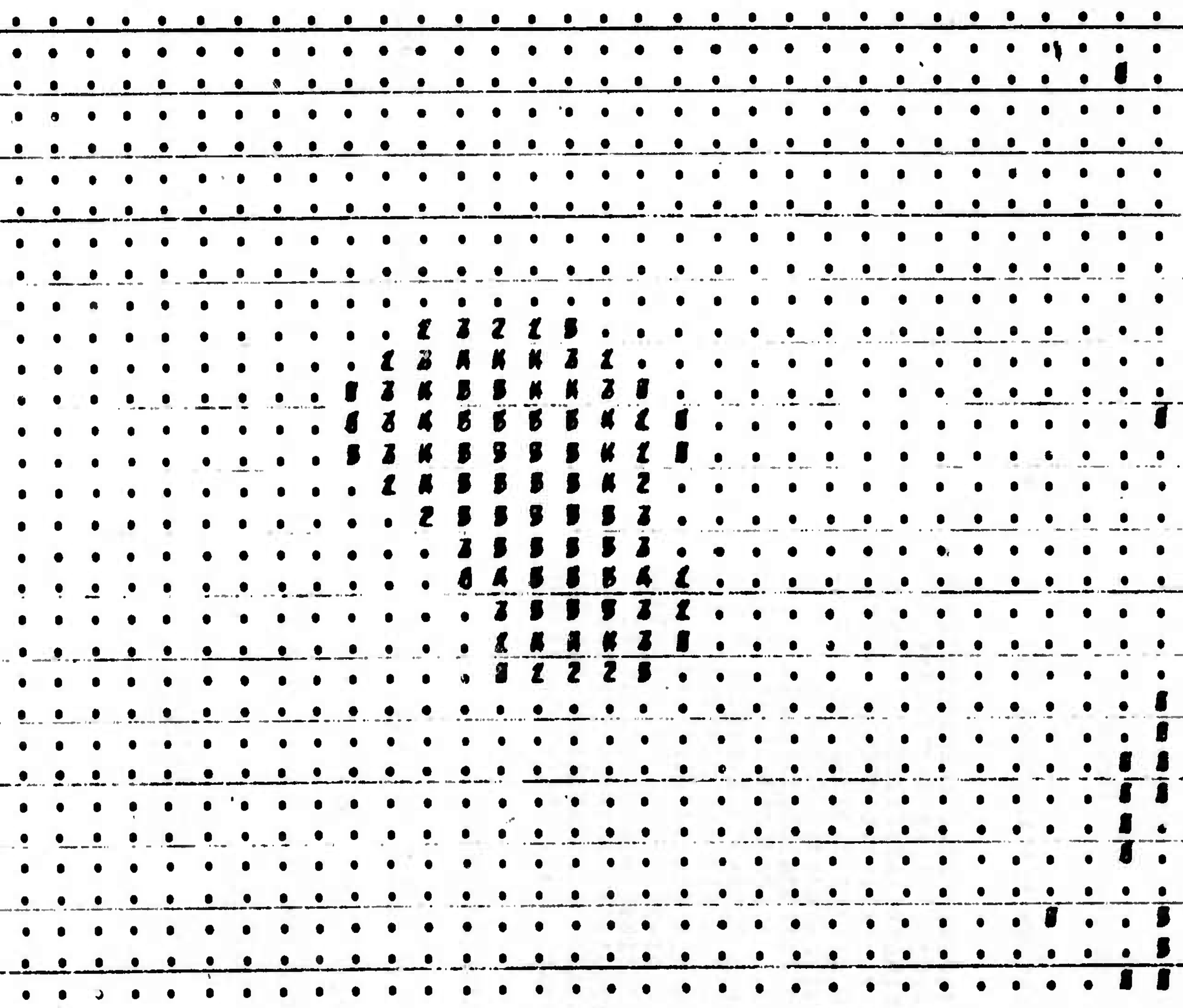
INPUT DATA DIVIDED BY 2

5	5	5	5	5	6	8	6	5	5	8	6	8	8	8	8	8	8	9	8	6	9	9	9	9	8	8	8	9	9	9	9
5	5	4	5	6	6	6	6	5	6	8	6	6	8	6	8	6	8	8	8	6	8	9	9	9	8	8	9	9	9	9	9
4	5	4	6	6	5	6	6	5	6	8	6	6	6	6	6	8	6	8	8	8	8	8	9	9	8	8	9	9	9	[illegible]	9
5	5	4	6	6	6	6	6	6	8	6	6	6	6	6	6	8	6	8	8	6	8	8	8	9	9	8	9	9	9	9	9
5	5	5	5	5	5	8	6	6	8	8	6	8	8	6	8	8	6	8	8	8	8	8	8	9	8	8	9	8	8	9	9
5	5	5	5	5	5	6	6	6	8	8	6	8	8	6	8	8	6	8	8	6	8	8	8	8	8	8	8	8	8	8	9
5	5	5	5	6	6	5	6	6	8	8	8	8	8	8	8	8	6	8	8	8	8	8	6	8	8	8	8	8	8	8	8
5	6	5	5	6	6	5	5	6	6	6	6	8	8	6	8	8	6	8	8	8	8	9	8	8	9	8	8	8	8	9	9
5	5	5	5	6	5	6	6	5	8	6	6	8	8	8	8	8	6	8	8	8	8	8	8	8	9	8	8	8	8	9	9
5	5	5	6	5	6	6	6	6	8	8	8	9	9	9	9	8	6	8	8	6	8	8	6	9	8	8	8	8	8	9	9
5	5	5	6	6	6	8	6	8	8	9	[illegible]	[illegible]	2	[illegible]	[illegible]	9	8	8	8	8	8	8	6	8	9	6	8	8	8	9	9
5	5	5	6	6	6	8	8	8	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	8	8	8	8	8	6	8	8	8	8	8	9	9	9
4	5	5	5	6	5	8	8	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	8	8	8	8	8	8	8	8	8	8	9	9	9
4	4	5	5	5	5	6	6	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	6	8	8	6	8	8	8	8	9	9	9	[illegible]
4	4	4	5	4	5	5	6	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	6	6	8	6	8	6	8	8	8	8	9	9
1	1	1	1	1	2	3	3	4	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	9	5	4	5	4	4	5	5	4	5	6	5	6	6
.	.	.	.	.	.	.	.	.	1	6	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	3	.	.	.	.	.	.	.	.	1	.	1	2
.	.	.	.	.	.	.	.	.	.	1	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	1	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	1	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	2	.	.	.	.	.	1	2	3	4	5	4
1	3	2	4	4	3	4	4	4	4	5	5	8	[illegible]	[illegible]	2	2	[illegible]	9	8	5	5	6	6	6	5	6	6	6	6	8	8
4	5	4	5	5	5	6	6	5	6	6	6	8	8	8	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	9	[illegible]
5	6	5	5	6	6	6	8	6	6	6	6	8	8	6	8	8	6	8	9	9	9	8	6	8	8	8	9	9	9	9	[illegible]
5	5	5	6	6	6	6	6	6	8	8	6	8	8	8	8	8	6	8	9	8	9	9	8	9	9	9	9	9	9	[illegible]	[illegible]
6	6	5	5	6	6	6	6	6	8	6	8	8	8	6	8	8	8	8	8	8	9	8	8	9	9	8	9	9	9	[illegible]	[illegible]
6	5	5	6	6	6	6	6	6	8	8	6	6	8	8	8	8	8	8	8	8	9	9	8	9	9	9	9	9	9	[illegible]	9
6	5	5	6	8	6	5	6	6	6	8	8	6	8	8	8	8	8	8	8	8	9	9	8	9	9	9	9	9	9	[illegible]	9
5	5	5	6	6	6	8	8	6	6	8	6	6	8	8	9	8	8	8	8	8	9	9	8	9	9	9	9	9	9	9	9
6	6	5	6	6	6	8	6	6	6	6	6	8	8	8	8	9	8	9	8	8	8	9	9	9	9	9	9	[illegible]	9	9	[illegible]
6	6	5	6	6	6	6	6	6	8	6	6	8	8	8	9	9	8	8	8	8	9	8	8	9	9	9	9	9	9	9	[illegible]
6	6	5	6	6	6	6	8	8	8	6	6	6	6	6	8	9	8	8	8	8	8	9	8	9	9	9	9	9	9	[illegible]	[illegible]

SAMPLE NO.100 RUN NO. 80

CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2



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SAMPLE NO.100     RUN NO.  80

CORRELATION REFERENCE MATRIX

141413171922232422211816161616 17
1415141823252728262420161616 1617
141516192528303028262217161616 16
13161621272931303029241816161514
11131620262931303029251917151413
 5 612172428313030292621171210 10
 0 1 2 7172530303030282215 7 1 1
 0 0 0 1 620283131302922 12 1 0 0
 0 0 0 0 21224303030292312 0 0 0
 0 0 0 0 0 6192830302923 13 2 0 0
 8 0 0 0 2 7182527282723 15 8 3 2
 6 7 8 81012172122242319151210 10
12131313151516161718191715151515
13141515161616161616171616161616
14151415141616171616161616161616
14151415151416161617171616161616

TRACKING ERRORS

EDGE ERRORS XM=  -.4088    YM=  1.6796     XC=   .4662   YC=  -.8829

CENTROID ERRORS XM= -1.2331    YM=  2.2236     XC=  -.3581   YC=  -.3389

CORRELATION ERRORS XM= -1.6229    YM=  1.9330     XC=  -.7479   YC=  -.6295

FRAME OFFSETS   -1    3     INPUT INCR. ERRORS        .1250       -.4375

FINAL SEARCH CORRELATIONS -
1.09E+03  5.74E+02  6.78E+02  8.90E+02  3.86E+02  4.88E+02  1.13E+03  6.26E+02  6.56E+02
```

STATISTICAL DATA

	RESOLUTION ELEMENTS				REGRESSION COEF	
CENTROID - X AXIS	MEAN	-7.255050E-02	RMS	2.178016E-01	BETA	4.039417E-04
CENTROID - Y AXIS	MEAN	4.479614E-01	RMS	4.096814E-01	BETA	1.366775E-03
RADIAL ERROR(RMS)=	.4640		DRIFT DISTANCE=	.1425		
DIG CORR - X AXIS	MEAN	-3.290501E-01	RMS	8.041711E-02	BETA	-6.472919E-03
DIG CORR - Y AXIS	MEAN	-2.303175E-01	RMS	6.782663E-02	BETA	-8.884379E-03
RADIAL ERROR(RMS)=	.1052		DRIFT DISTANCE=	1.0992		
EDGE - X AXIS	MEAN	6.391474E-01	RMS	1.941887E+00	BETA	1.002971E-02
EDGE - Y AXIS	MEAN	-4.676744E-01	RMS	2.296700E-01	BETA	-6.585136E-03
RADIAL ERROR(RMS)=	1.9554		DRIFT DISTANCE=	1.1998		

TRACKING ERRORS

CENTROID - X AXIS

-.1470	-.4167	.1548	-.3712	-.3676	-.5013	-.0344	.3303	-.0624	-.0762
-.5633	-.3233	-.3445	-.1934	-.4015	.2107	.1714	-.6105	-.5422	-.2693
-.2458	-.4475	.0432	-.3160	.3702	-.4209	.0509	-.2703	.4538	.1860
-.2614	-.2240	.2518	-.2363	.3283	-.2290	-.0647	.1100	.3023	.1382
-.2355	.5853	.2158	.3868	.1765	.1108	.4549	.1119	-.1152	.4714
.6768	-.1775	-.3087	.0623	-.0111	-.0838	-.0111	-.3593	-.6584	.1713
.1115	-.2208	-.3909	-.2390	-.1906	-.2548	-.3817	.3179	.3133	-.1300
.3398	.2582	.0538	.0174	-.4668	-.4629	-.4340	-.3255	-.0602	-.3615
.0874	-.1677	-.2651	.1946	.0058	-.1570	.2613	-.1650	.3212	-.1632
-.2878	-.2333	-.0891	-.3644	.1592	-.4233	-.3237	.2204	-.1776	-.3854

CENTROID - Y AXIS

.0853	.0905	.0240	-.4703	-.4037	-.3840	.2135	.6536	-.3633	-.1219
.6996	.6924	.6132	.2047	-.0344	.4564	1.4365	1.3290	.7601	-.1160
.4013	-.2244	.3002	1.2846	.5287	1.4389	.3302	.3922	.6362	.2709
.5237	-.3365	.4523	.3769	.3677	.3104	.3825	1.3811	.5397	.4273
.8935	1.0418	.4068	.8122	.4636	.4385	.8270	.6720	1.2958	.8185
1.4945	1.3518	1.2148	.3108	.9040	.0410	.3648	.4517	-.3434	.1306
.3299	-.1745	-.3683	-.0179	-.0831	.0257	.1611	1.0669	.8785	.5344
1.3490	1.0153	.5270	.6081	.7408	.1372	-.2632	.2176	.0729	-.1005
.6762	.0768	.3310	.8260	.2348	.8240	.5748	.5442	.9163	.7366
-.2126	.6888	.0691	-.3591	.8942	-.4743	.3669	1.0055	1.2108	.3535

DIG CORR - X AXIS

.0410	.0796	-.0813	-.1334	-.1817	-.0314	-.1625	-.0434	.0088	-.1681
-.2078	-.1799	-.3220	-.0186	-.1078	-.0958	-.1992	-.3107	-.2484	-.2541
-.2342	-.2150	-.2427	-.0504	-.0427	-.1101	-.0519	-.1152	-.1096	-.1811
-.0787	-.2576	-.1592	-.1868	-.0106	-.1387	-.2104	-.1827	-.0866	-.1052
-.1559	-.2305	-.1429	-.1568	-.2133	-.1634	-.2460	-.2754	-.1884	-.3526
-.2472	-.2318	-.3011	-.2526	-.3344	-.2863	-.2493	-.3329	-.4829	-.4960
-.4166	-.3808	-.4752	-.5305	-.4825	-.6243	-.5501	-.4191	-.4017	-.4324
-.5311	-.4683	-.5928	-.5806	-.5341	-.6010	-.6089	-.5828	-.6087	-.5631
-.4879	-.6197	-.5209	-.4579	-.5186	-.5061	-.5380	-.5035	-.5899	-.6236
-.6511	-.5954	-.5745	-.5911	-.6378	-.6455	-.5980	-.6511	-.6941	-.7479

DIG CORR - Y AXIS

.2154	.2715	.2164	.2852	.2035	.0965	.0859	.0299	.0726	.1438
.0247	.0672	.0802	.0243	.1103	.0905	.0158	.0013	.0998	.0280
.1230	.0496	.0369	.0058	.0418	.0017	.0557	-.0116	.0637	-.0373
-.0526	.1195	-.0071	-.0569	-.0115	-.1372	-.1647	-.1196	-.0481	-.1165
-.1559	-.0335	-.1753	-.1381	-.2447	-.1967	-.2271	-.2820	-.3104	-.2189
-.1716	-.3218	-.3352	-.2566	-.2774	-.2885	-.1951	-.1719	-.2672	-.2388
-.1968	-.2569	-.3135	-.2535	-.3589	-.4483	-.5394	-.5559	-.5792	-.4728
-.3609	-.4731	-.5635	-.3931	-.3087	-.5984	-.2799	-.2866	-.4664	-.5020
-.5513	-.5327	-.5166	-.3988	-.5541	-.4206	-.4399	-.6002	-.6356	-.5403
-.5797	-.6177	-.6652	-.7611	-.7224	-.6423	-.7210	-.6473	-.6583	-.6295

TRACKING ERRORS (Continued)

EDGE - X AXIS

-4.7837	1.3364	-4.2247	-2.7987	2.4770	.5331	-2.6066	2.4804	1.6654	.7224
2.4058	-2.3639	-.1224	-1.6552	-5.5295	-1.2363	5.1836	-1.5416	.2091	-1.1794
1.5268	-.0777	.1366	-2.2279	.1684	-5.2868	-4.9902	-2.8530	6.5665	-.0937
2.3683	2.4187	4.1203	1.9866	1.7809	-.2816	.1040	2.8590	6.0404	2.3098
.9888	2.5312	2.1334	2.4622	1.5870	1.2136	9.9040	.7033	.6368	.2249
3.9753	.9136	-.4129	-3.7384	.7753	-1.8447	.8658	.0204	2.2002	2.0359
.1372	-4.5929	-2.4417	.9964	1.2311	5.6353	1.4449	2.7893	3.2294	-.4425
2.3273	2.0236	2.6294	-1.2566	-2.2593	3.9015	.5838	-.4759	4.4095	.4962
.2794	-.9933	2.0916	2.1709	-1.7366	.5861	-.1932	-1.4587	5.0524	2.0283
-1.9675	-1.7776	-3.6134	4.6754	.4259	-1.1691	.3218	1.6081	1.5184	-1.4568

EDGE - Y AXIS

-.7492	-.4553	-.6030	.1787	-.3036	.2945	-.3612	.0064	-.3606	-.9337
.1249	-.0218	.0961	-.2271	-.3942	-.5139	.2790	.0672	-.6050	.0246
-.9646	-.0912	-.6044	-.0539	-.2567	.2136	-.4172	-.6158	-.3274	-.2397
-.5305	-.6700	-.6170	-.9850	-.1648	-.1439	-.1615	.5015	.0756	-.6710
-.3214	-.7972	-.6850	-.6829	-.6647	-.4430	-.3083	-.4698	.1697	-.6891
-.7581	.1069	.1077	-1.1122	-.3112	-.6871	-.3646	-.5374	-.3691	-.1398
-.5979	-.6562	-.4801	-.6492	-.6813	-.7805	.0053	-.7204	-.7784	-1.2606
-.8991	-.7886	-.9055	-.9295	.1768	-.6102	-.4517	-.7462	-.4615	-.4192
-.5675	-.7605	-.6629	-.6352	-.2824	-.5644	-.6483	-.3155	-.7329	-1.1465
-.5233	-.3829	-1.1827	-.7276	-.8729	-1.0950	-1.3807	-.6224	-.7500	-.6765

FILTERED TRACKER DATA

CENTROID - X AXIS

0.0000	0.0000	-.0845	-.2010	-.3020	-.4417	-.3395	.0174	.1913	.0933
-.2637	-.4673	-.4606	-.3019	-.2610	-.0980	.1063	-.0650	-.4311	-.5512
-.3906	-.2981	-.1725	-.1620	.0301	-.0287	-.0749	-.1789	.0351	.2432
.1340	-.1483	-.1290	-.0656	.1028	.0491	-.0534	-.0543	.1287	.2422
.0758	.1326	.2627	.3874	.3234	.1866	.2195	.2426	.1060	.1358
.4149	.3672	-.0224	-.2279	-.1407	-.0218	.0057	-.1428	-.4345	-.3555
-.0397	.0725	-.1475	-.3388	-.3248	-.2414	-.2635	-.0818	.2042	.2212
.1827	.1991	.1869	.0893	-.1828	-.4358	-.5328	-.4469	-.2323	-.1726
-.0919	-.0805	-.1484	-.0770	.0310	.0119	.0505	.0125	.1022	.0560
-.1168	-.2766	-.2475	-.2339	-.0959	-.1392	-.2642	-.1316	-.0064	-.1151

CENTROID - Y AXIS

0.0000	0.0000	.0482	-.1350	-.3748	-.4815	-.2113	.3104	.3147	-.0006
.0727	.4903	.7679	.5893	.1809	.0891	.6639	1.3087	1.3404	.6213
.0987	-.1436	.0007	.5959	.9296	1.1712	.9153	.5335	.3731	.3600
.4325	.1656	.0906	.2190	.3997	.4136	.3694	.7371	.9226	.7500
.6213	.7906	.7894	.7223	.5809	.4781	.5634	.6928	.9808	1.0630
1.2182	1.3443	1.3613	.9165	.6248	.3376	.2470	.2994	.1252	-.0213
.0614	.0878	-.1196	-.2315	-.1697	-.0264	.1007	.5202	.9067	.9094
.9640	1.0523	.9133	.6511	.5664	.4308	.0785	-.0786	-.0135	.0343
.2623	.3366	.3328	.4825	.5167	.6083	.6351	.6192	.6991	.7815
.4353	.2693	.1898	-.0098	.1781	.1233	.1353	.4515	.9990	.9394

DIG CORR - X AXIS

0.0000	0.0000	-.0018	-.0642	-.1531	-.1420	-.1195	-.0825	-.0353	-.0585
-.1458	-.2097	-.2652	-.1937	-.1040	-.0593	-.1156	-.2309	-.2953	-.2897
-.2501	-.2193	-.2188	-.1606	-.0755	-.0468	-.0570	-.0890	-.1100	-.1449
-.1368	-.1597	-.1893	-.1961	-.1192	-.0768	-.1232	-.1888	-.1731	-.1178
-.1055	-.1640	-.1939	-.1340	-.1808	-.1806	-.2053	-.2463	-.2465	-.2743
-.2837	-.2664	-.2609	-.2634	-.2938	-.3070	-.2873	-.2868	-.3698	-.4739
-.4910	-.4305	-.4092	-.4637	-.5105	-.5646	-.5827	-.5227	-.4297	-.4126
-.4740	-.5122	-.5460	-.5731	-.5724	-.5731	-.5895	-.5998	-.6030	-.5875
-.5401	-.5426	-.5498	-.5187	-.4907	-.4913	-.5183	-.5249	-.5467	-.5895
-.6376	-.6399	-.6045	-.5775	-.5950	-.6323	-.6326	-.6286	-.6530	-.7093

DIG CORR - Y AXIS

0.0000	0.0000	.1940	.3122	.2884	.1815	.0871	.0344	.0375	.0384
.0951	.0731	.0596	.0487	.0661	.0881	.0718	.0256	.0299	.0470
.0840	.0865	.0623	.0234	.0140	.0131	.0300	.0232	.0309	.0108
-.0265	.0137	.0326	.0077	-.0291	-.0818	-.1373	-.1573	-.1122	-.0810
-.1047	-.1214	-.1415	-.1714	-.2179	-.2304	-.2255	-.2417	-.2832	-.2803
-.2241	-.2264	-.2388	-.3160	-.2957	-.2750	-.2417	-.1969	-.2012	-.2513
-.2606	-.2478	-.2638	-.2789	-.3122	-.3807	-.4812	-.5559	-.5876	-.5472
-.4451	-.4308	-.4635	-.4885	-.4110	-.4240	-.4072	-.3456	-.3441	-.4316
-.5326	-.5677	-.5473	-.4724	-.4633	-.4611	-.4539	-.4986	-.5873	-.6152
-.5920	-.5823	-.6210	-.7100	-.7481	-.7181	-.6675	-.6650	-.6579	-.6432

FILTERED TRACKER DATA (Continued)

EDGE - X AXIS

0.0000	0.0000	-1.9243	-3.1061	-1.4394	.8284	.4309	.2050	.9454	1.5450
1.8527	.3389	-.8390	-1.5606	-3.1410	-3.4280	.1094	1.9616	1.3566	-.5786
-.4853	.1915	.5145	-.6244	-1.0639	-2.6372	-4.4360	-4.7226	.0136	3.0725
3.4139	2.3283	2.6813	2.9183	2.4646	.9897	-.1038	.6975	3.5611	4.6716
3.1419	1.6392	1.4892	2.1527	2.2475	1.7210	4.5086	5.0928	2.9982	.2029
.7763	1.8806	1.3964	-1.3346	-2.0174	-1.6128	-.3231	.3108	1.2144	1.9483
1.5644	-1.2727	-3.4446	-2.3488	.3596	3.6025	4.0893	3.1904	2.5298	1.4125
1.1074	1.4872	2.3327	1.2849	-.9748	-.2868	1.2197	1.2829	1.8830	1.9511
1.2660	-.2320	.0045	1.3807	.9863	.0747	-.4488	-.7853	1.2256	2.9415
1.6799	-1.0888	-3.3186	-.8851	1.6585	1.5054	.0577	.0622	1.1131	.6743

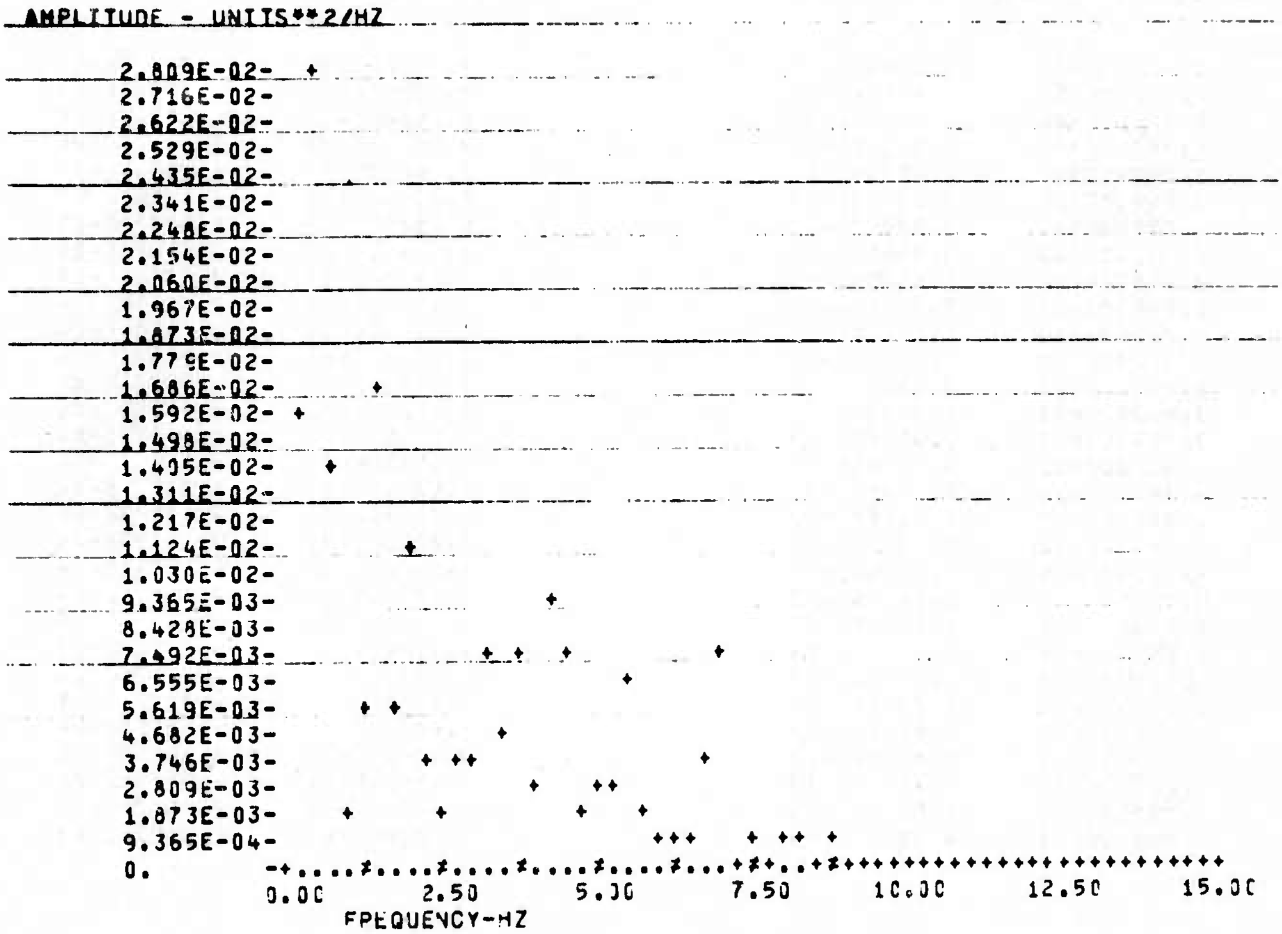
EDGE - Y AXIS

0.0000	0.0000	-.4742	-.4190	-.2076	.0841	.0169	-.0802	-.2359	-.5568
-.4858	-.1704	1247	.0596	-.2149	-.4762	-.2741	.0520	-.0521	-.2027
-.5372	-.5225	-.4869	-.2858	-.1854	-.0005	-.0724	-.3641	-.5300	-.4507
-.3922	-.5060	-.6385	-.8141	-.6460	-.3054	-.0676	.1917	.2739	-.0852
-.4451	-.6978	-.7522	-.7308	-.6775	-.5656	-.4070	-.3535	-.1626	-.2473
-.5402	-.4768	-.1014	-.2702	-.5348	-.7009	-.5671	-.4687	-.4024	-.3124
-.3667	-.5393	-.6176	-.6214	-.6331	-.7100	-.4785	-.3952	-.5509	-.9566
-1.1396	-1.0105	-.8454	-.8314	-.4803	-.2845	-.3108	-.5715	-.6510	-.5472
-.4699	-.5764	-.6981	-.7138	-.5234	-.4206	-.4952	-.5066	-.5617	-.8185
-.8757	-.6424	-.6772	-.8136	-.9109	-.9762	-1.1728	-1.0779	-.8309	-.6344

SPECTRAL DENSITY CENTROID - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.58489E-02
5.00000E-01	2.80949E-02
7.50000E-01	1.36738E-02
1.00000E+00	1.74353E-03
1.25000E+00	5.23213E-03
1.50000E+00	1.69890E-02
1.75000E+00	5.89841E-03
2.00000E+00	1.14114E-02
2.25000E+00	3.87274E-03
2.50000E+00	2.03396E-03
2.75000E+00	4.13472E-03
3.00000E+00	3.99006E-03
3.25000E+00	7.90871E-03
3.50000E+00	4.77375E-03
3.75000E+00	7.89312E-03
4.00000E+00	2.74123E-03
4.25000E+00	9.39272E-03
4.50000E+00	7.63970E-03
4.75000E+00	1.42454E-03
5.00000E+00	2.59307E-03
5.25000E+00	2.75957E-03
5.50000E+00	6.74790E-03
5.75000E+00	1.73564E-03
6.00000E+00	6.04597E-04
6.25000E+00	1.00889E-03
6.50000E+00	1.09039E-03
6.75000E+00	3.90480E-03
7.00000E+00	7.30024E-03
7.25000E+00	1.12459E-04
7.50000E+00	5.69003E-04
7.75000E+00	2.66867E-04
8.00000E+00	8.37268E-04
8.25000E+00	5.85415E-04
8.50000E+00	2.58840E-04
8.75000E+00	5.05485E-04
9.00000E+00	2.45701E-04
9.25000E+00	1.66109E-04
9.50000E+00	2.78692E-04
9.75000E+00	1.53996E-04
1.00000E+01	2.02677E-04
1.02500E+01	2.50903E-04
1.05000E+01	3.89692E-05
1.07500E+01	5.64803E-05
1.10000E+01	1.57830E-04
1.12500E+01	8.90657E-05
1.15000E+01	6.86903E-05
1.17500E+01	5.48132E-05
1.20000E+01	6.75154E-06
1.22500E+01	1.33198E-04
1.25000E+01	1.46695E-06
1.27500E+01	3.06981E-05
1.30000E+01	1.74201E-05
1.32500E+01	3.32919E-05
1.35000E+01	1.07903E-05
1.37500E+01	9.76998E-05
1.40000E+01	1.19844E-04
1.42500E+01	3.58687E-05
1.45000E+01	1.96939E-04
1.47500E+01	1.17514E-05
1.50000E+01	1.52014E-04

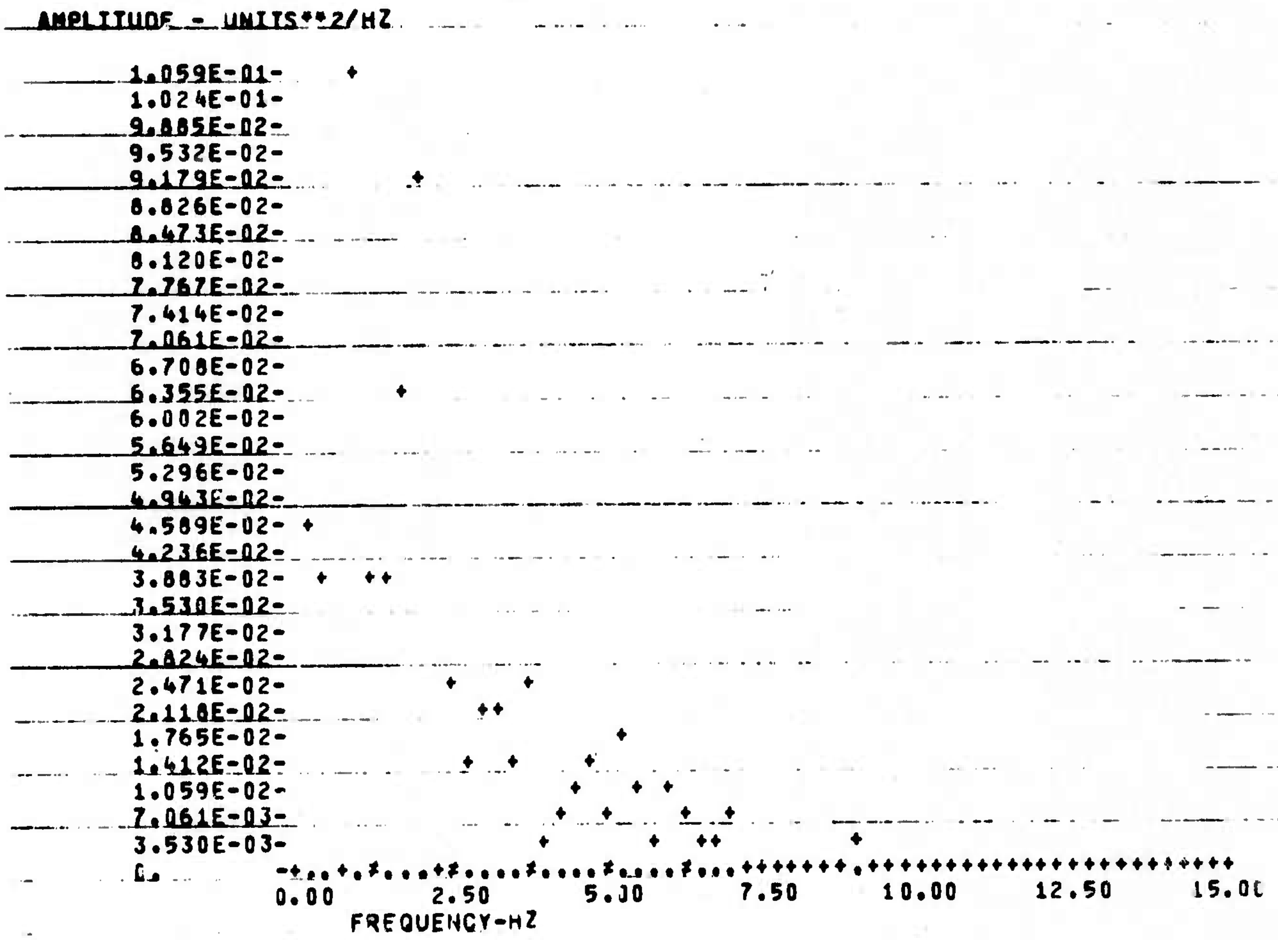
SPECTRAL DENSITY CENTROID - X AXIS



SPECTRAL DENSITY CENTROID - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	4.52243E-02	7.75000E+00	1.75022E-03
5.00000E-01	3.94658E-02	8.00000E+00	1.37597E-03
7.50000E-01	1.44150E-03	8.25000E+00	1.49746E-05
1.00000E+00	1.05911E-01	8.50000E+00	2.50974E-04
1.25000E+00	3.77839E-02	8.75000E+00	1.76041E-03
1.50000E+00	3.87153E-02	9.00000E+00	2.10651E-03
1.75000E+00	6.43743E-02	9.25000E+00	5.55798E-05
2.00000E+00	9.35550E-02	9.50000E+00	3.59657E-04
2.25000E+00	1.49965E-03	9.75000E+00	8.87711E-05
2.50000E+00	2.59718E-02	1.00000E+01	9.50836E-04
2.75000E+00	1.23670E-02	1.02500E+01	4.98506E-04
3.00000E+00	2.23148E-02	1.05000E+01	2.14688E-04
3.25000E+00	2.21308E-02	1.07500E+01	2.29903E-04
3.50000E+00	1.30332E-02	1.10000E+01	1.44713E-04
3.75000E+00	2.30235E-02	1.12500E+01	1.45663E-04
4.00000E+00	4.56160E-03	1.15000E+01	4.64477E-04
4.25000E+00	8.65418E-03	1.17500E+01	2.40031E-04
4.50000E+00	1.21097E-02	1.20000E+01	3.11073E-06
4.75000E+00	1.52810E-02	1.22500E+01	3.02853E-04
5.00000E+00	7.19764E-03	1.25000E+01	1.01723E-04
5.25000E+00	1.59955E-02	1.27500E+01	2.16016E-04
5.50000E+00	1.06350E-02	1.30000E+01	3.54706E-04
5.75000E+00	2.90079E-03	1.32500E+01	5.53246E-05
6.00000E+00	1.05526E-02	1.35000E+01	4.70425E-04
6.25000E+00	7.72251E-03	1.37500E+01	4.80232E-05
6.50000E+00	4.52146E-03	1.40000E+01	5.08429E-05
6.75000E+00	3.82580E-03	1.42500E+01	8.89348E-05
7.00000E+00	6.30964E-03	1.45000E+01	1.90781E-06
7.25000E+00	2.50710E-04	1.47500E+01	5.86671E-05
7.50000E+00	4.38257E-04	1.50000E+01	6.32936E-07

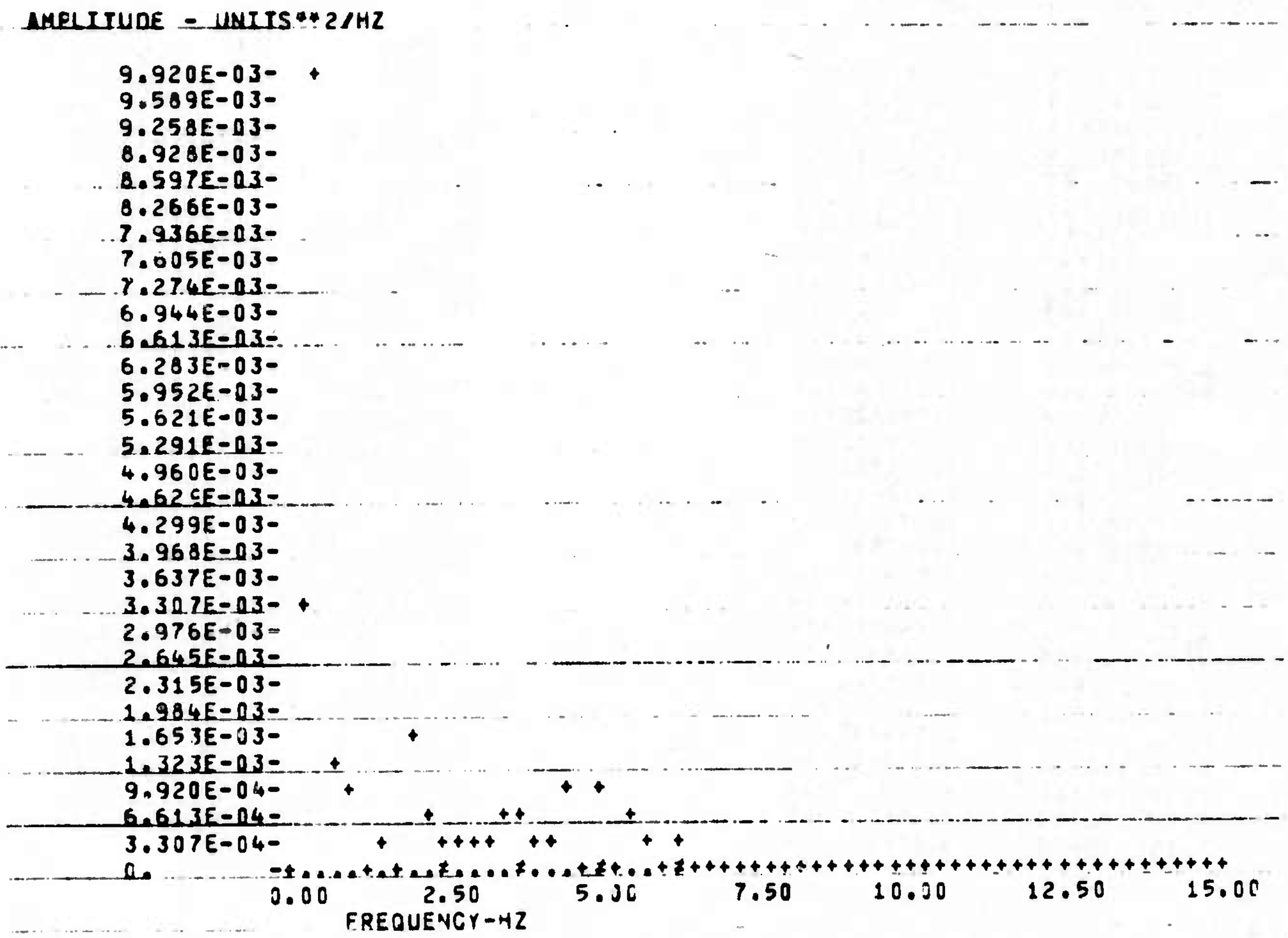
SPECTRAL DENSITY CENTROID - Y AXIS



SPECTRAL DENSITY DIG CORR - X AXIS

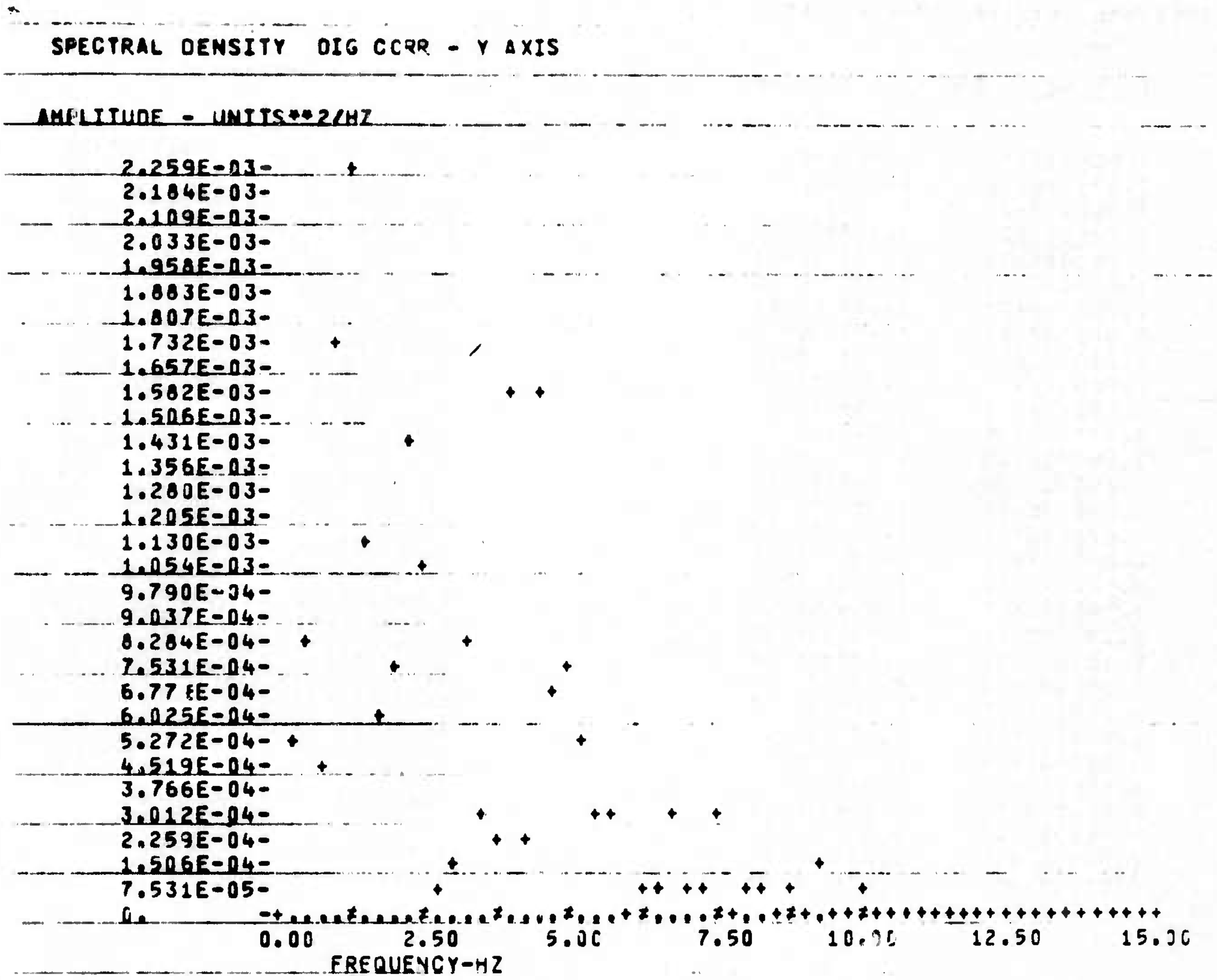
FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	3.15353E-03	7.75000E+00	2.02741E-05
5.00000E-01	9.91977E-03	8.00000E+00	3.55216E-05
7.50000E-01	1.47023E-03	8.25000E+00	6.06350E-05
1.00000E+00	8.77312E-04	8.50000E+00	4.83874E-06
1.25000E+00	6.75957E-05	8.75000E+00	7.77341E-08
1.50000E+00	3.15375E-04	9.00000E+00	1.37351E-05
1.75000E+00	3.33756E-05	9.25000E+00	1.63553E-05
2.00000E+00	1.80048E-03	9.50000E+00	2.40895E-05
2.25000E+00	7.57671E-04	9.75000E+00	7.11274E-06
2.50000E+00	3.77809E-04	1.00000E+01	2.60408E-06
2.75000E+00	2.58631E-04	1.02500E+01	1.51633E-06
3.00000E+00	3.94299E-04	1.05000E+01	1.21056E-05
3.25000E+00	3.69091E-04	1.07500E+01	5.10339E-06
3.50000E+00	7.95222E-04	1.10000E+01	9.12601E-06
3.75000E+00	5.81653E-04	1.12500E+01	1.11149E-05
4.00000E+00	4.83226E-04	1.15000E+01	3.93200E-06
4.25000E+00	2.64590E-04	1.17500E+01	6.67969E-06
4.50000E+00	9.24452E-04	1.20000E+01	8.02320E-06
4.75000E+00	6.53256E-05	1.22500E+01	2.05150E-08
5.00000E+00	8.92724E-04	1.25000E+01	2.60486E-06
5.25000E+00	5.99326E-05	1.27500E+01	1.67918E-06
5.50000E+00	4.96165E-04	1.30000E+01	9.88587E-07
5.75000E+00	2.51663E-04	1.32500E+01	8.53914E-06
6.00000E+00	4.11816E-05	1.35000E+01	2.39977E-06
6.25000E+00	2.15907E-04	1.37500E+01	4.59591E-06
6.50000E+00	1.31286E-04	1.40000E+01	1.52143E-06
6.75000E+00	1.15795E-04	1.42500E+01	6.04250E-06
7.00000E+00	4.31358E-05	1.45000E+01	1.15140E-05
7.25000E+00	1.21679E-04	1.47500E+01	4.94072E-07
7.50000E+00	4.62390E-05	1.50000E+01	3.01092E-06

SPECTRAL DENSITY DIG CORR - X AXIS



SPECTRAL DENSITY DIG CORR - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	5.58181E-04
5.00000E-01	7.90989E-04
7.50000E-01	4.78939E-04
1.00000E+00	1.75749E-03
1.25000E+00	2.25930E-03
1.50000E+00	1.15070E-03
1.75000E+00	5.84856E-04
2.00000E+00	7.35821E-04
2.25000E+00	1.45427E-03
2.50000E+00	1.07650E-03
2.75000E+00	9.01270E-05
3.00000E+00	1.87644E-04
3.25000E+00	8.19304E-04
3.50000E+00	3.06577E-04
3.75000E+00	2.28428E-04
4.00000E+00	1.55831E-03
4.25000E+00	2.42794E-04
4.50000E+00	1.57367E-03
4.75000E+00	7.01983E-04
5.00000E+00	7.72565E-04
5.25000E+00	5.16402E-04
5.50000E+00	2.74490E-04
5.75000E+00	3.27883E-04
6.00000E+00	2.01058E-05
6.25000E+00	1.00271E-04
6.50000E+00	4.05405E-05
6.75000E+00	3.33344E-04
7.00000E+00	4.15374E-05
7.25000E+00	9.05665E-05
7.50000E+00	3.10798E-04
7.75000E+00	2.98977E-06
8.00000E+00	4.87629E-05
8.25000E+00	1.02767E-04
8.50000E+00	1.19066E-05
8.75000E+00	9.70325E-05
9.00000E+00	5.85865E-06
9.25000E+00	1.44621E-04
9.50000E+00	5.48072E-06
9.75000E+00	5.53025E-06
1.00000E+01	4.45137E-05
1.02500E+01	6.63716E-06
1.05000E+01	9.15719E-07
1.07500E+01	1.21487E-05
1.10000E+01	7.91529E-06
1.12500E+01	1.87954E-05
1.15000E+01	2.28581E-06
1.17500E+01	4.54841E-06
1.20000E+01	1.23447E-05
1.22500E+01	7.44006E-06
1.25000E+01	4.61109E-06
1.27500E+01	5.76521E-06
1.30000E+01	1.36502E-06
1.32500E+01	1.15816E-05
1.35000E+01	5.38338E-06
1.37500E+01	3.07986E-07
1.40000E+01	5.21817E-06
1.42500E+01	4.53669E-06
1.45000E+01	4.26055E-06
1.47500E+01	4.53337E-06
1.50000E+01	2.61692E-06

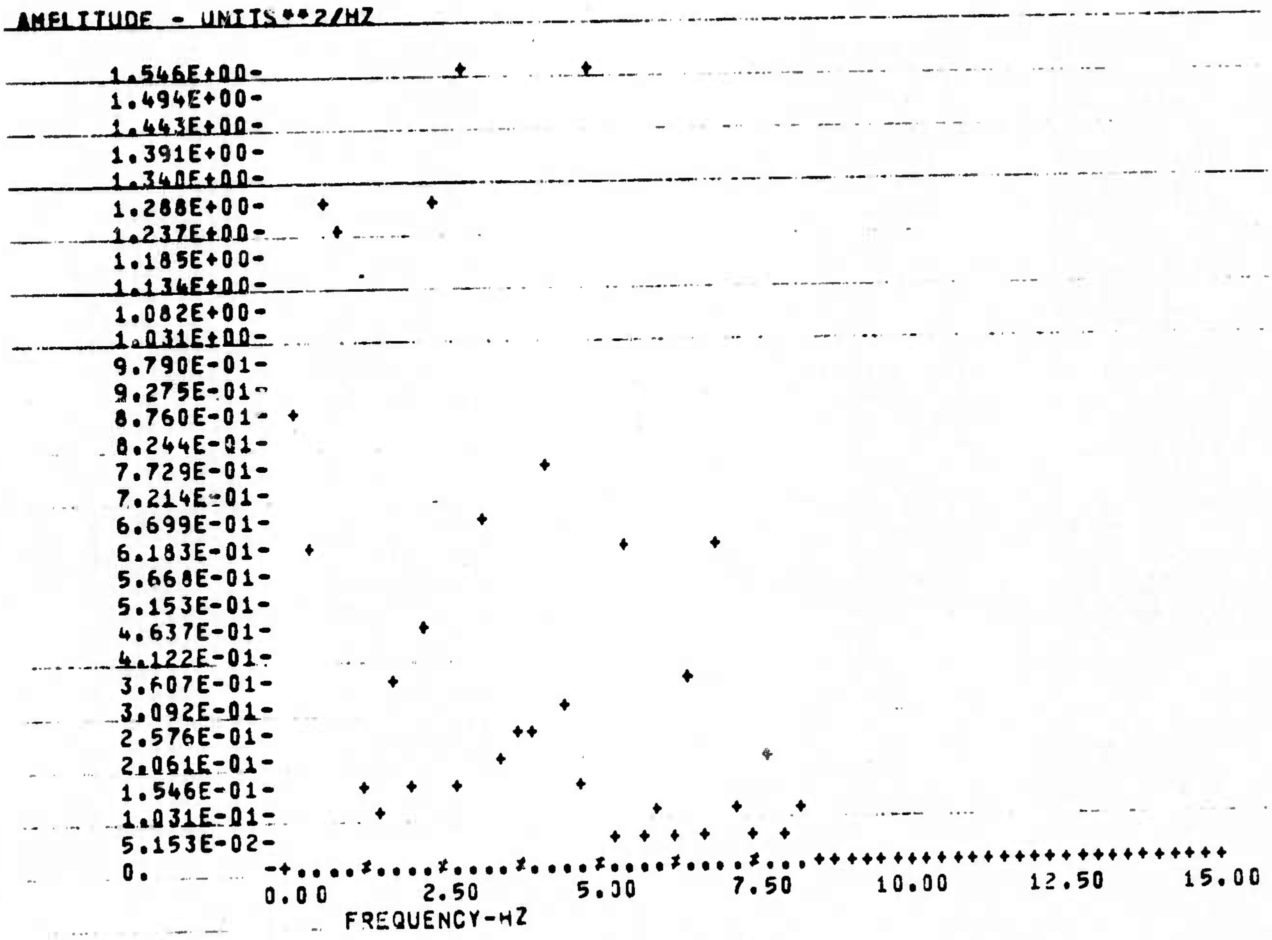


SPECTRAL DENSITY DIG CORR - Y AXIS
AMPLITUDE - UNITS**2/HZ
2.259E-03-
2.184E-03-
2.109E-03-
2.033E-03-
1.958E-03-
1.883E-03-
1.807E-03-
1.732E-03-
1.657E-03-
1.582E-03-
1.506E-03-
1.431E-03-
1.356E-03-
1.280E-03-
1.205E-03-
1.130E-03-
1.054E-03-
9.790E-04-
9.037E-04-
8.284E-04-
7.531E-04-
6.778E-04-
6.025E-04-
5.272E-04-
4.519E-04-
3.766E-04-
3.012E-04-
2.259E-04-
1.506E-04-
7.531E-05-
0.
0.00
2.50
5.00
7.50
10.00
12.50
15.00
FREQUENCY-HZ

SPECTRAL DENSITY EDGE - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	8.64098E-01	7.75000E+00	1.86920E-01
5.00000E-01	6.31949E-01	8.00000E+00	3.71147E-02
7.50000E-01	1.27508E+00	8.25000E+00	1.01903E-01
1.00000E+00	1.22835E+00	8.50000E+00	2.46061E-02
1.25000E+00	1.44732E-01	8.75000E+00	1.83508E-02
1.50000E+00	1.27544E-01	9.00000E+00	1.07947E-03
1.75000E+00	3.39040E-01	9.25000E+00	4.58002E-03
2.00000E+00	1.40086E-01	9.50000E+00	1.09591E-02
2.25000E+00	4.79735E-01	9.75000E+00	1.25807E-02
2.50000E+00	1.29142E+00	1.00000E+01	2.08747E-02
2.75000E+00	1.74644E-01	1.02500E+01	4.57875E-03
3.00000E+00	1.54583E+00	1.05000E+01	1.30459E-04
3.25000E+00	6.59242E-01	1.07500E+01	7.99627E-03
3.50000E+00	1.84656E-01	1.10000E+01	2.97030E-03
3.75000E+00	2.68499E-01	1.12500E+01	3.01009E-03
4.00000E+00	2.48009E-01	1.15000E+01	1.35271E-02
4.25000E+00	7.98196E-01	1.17500E+01	2.08485E-03
4.50000E+00	2.84961E-01	1.20000E+01	1.30843E-02
4.75000E+00	1.61440E-01	1.22500E+01	2.93942E-03
5.00000E+00	1.54199E+00	1.25000E+01	2.38728E-05
5.25000E+00	3.35546E-02	1.27500E+01	2.74109E-03
5.50000E+00	6.02968E-01	1.30000E+01	2.67250E-03
5.75000E+00	6.35039E-02	1.32500E+01	3.47300E-03
6.00000E+00	1.07733E-01	1.35000E+01	1.24994E-04
6.25000E+00	6.25553E-02	1.37500E+01	3.72298E-03
6.50000E+00	3.66046E-01	1.40000E+01	8.48334E-03
6.75000E+00	3.69487E-02	1.42500E+01	2.50055E-03
7.00000E+00	5.96228E-01	1.45000E+01	2.05384E-03
7.25000E+00	1.22311E-01	1.47500E+01	1.14682E-02
7.50000E+00	3.48663E-02	1.50000E+01	2.16399E-02

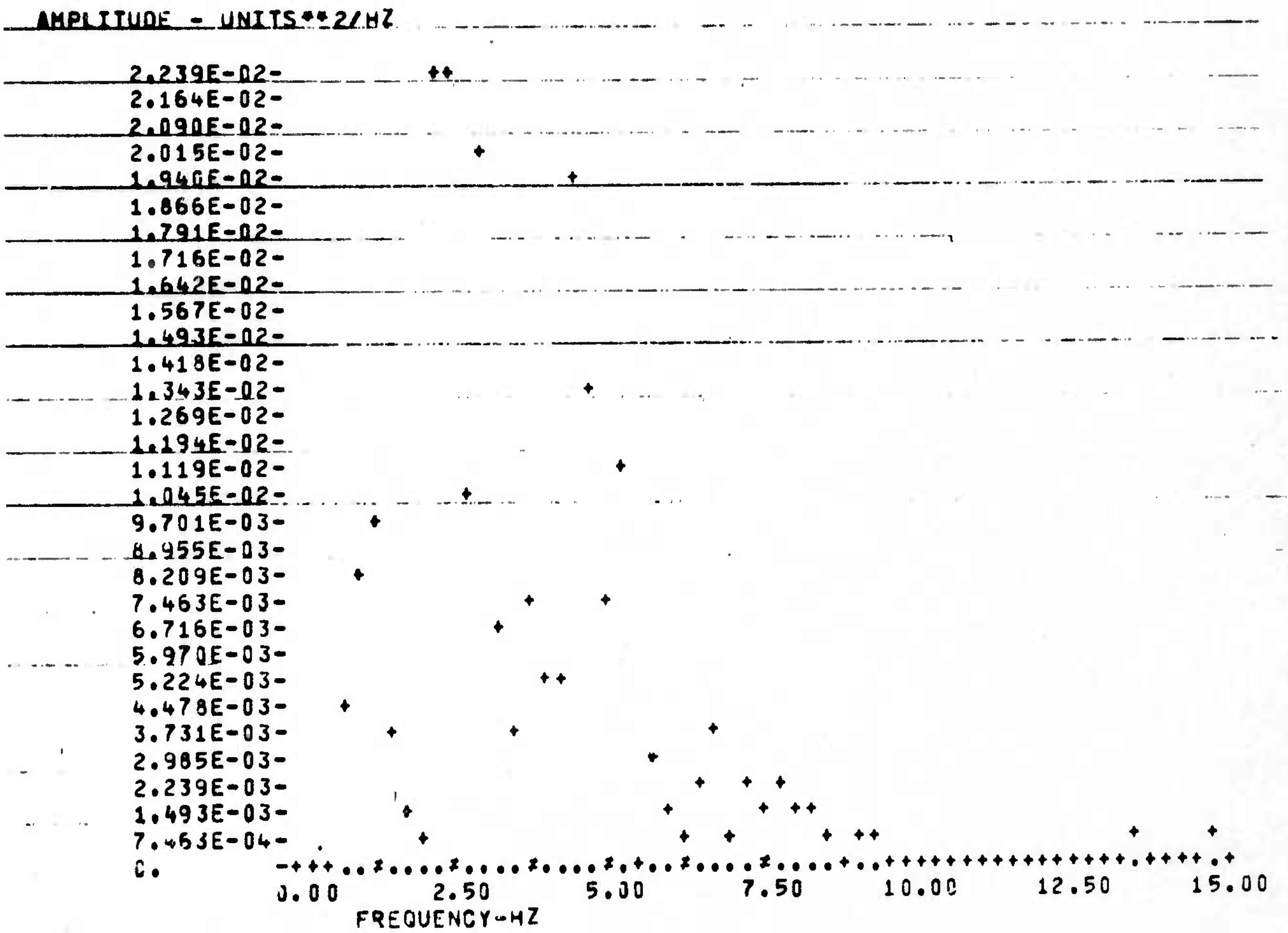
SPECTRAL DENSITY EDGE - X AXIS



SPECTRAL DENSITY EDGE - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	3.24020E-04	7.75000E+00	2.02015E-03
5.00000E-01	2.58770E-05	8.00000E+00	1.76474E-03
7.50000E-01	4.73217E-03	8.25000E+00	1.19317E-03
1.00000E+00	8.28540E-03	8.50000E+00	1.10613E-03
1.25000E+00	9.83886E-03	8.75000E+00	1.64977E-04
1.50000E+00	3.44354E-03	9.00000E+00	7.20304E-04
1.75000E+00	1.35714E-03	9.25000E+00	7.67906E-04
2.00000E+00	8.29794E-04	9.50000E+00	1.20744E-04
2.25000E+00	2.23876E-02	9.75000E+00	1.32915E-04
2.50000E+00	2.21763E-02	1.00000E+01	1.79945E-04
2.75000E+00	1.03088E-02	1.02500E+01	1.17389E-04
3.00000E+00	2.01075E-02	1.05000E+01	1.77655E-04
3.25000E+00	6.86794E-03	1.07500E+01	1.85227E-04
3.50000E+00	3.79064E-03	1.10000E+01	1.39769E-04
3.75000E+00	7.11589E-03	1.12500E+01	2.26496E-04
4.00000E+00	5.17510E-03	1.15000E+01	5.90521E-05
4.25000E+00	5.17917E-03	1.17500E+01	4.05894E-05
4.50000E+00	1.96454E-02	1.20000E+01	4.31320E-05
4.75000E+00	1.35403E-02	1.22500E+01	1.22712E-04
5.00000E+00	7.73049E-03	1.25000E+01	7.20682E-06
5.25000E+00	1.08576E-02	1.27500E+01	1.36876E-04
5.50000E+00	1.28544E-04	1.30000E+01	1.34776E-04
5.75000E+00	2.62102E-03	1.32500E+01	1.06886E-04
6.00000E+00	1.33945E-03	1.35000E+01	3.88606E-04
6.25000E+00	5.25039E-04	1.37500E+01	1.39593E-04
6.50000E+00	2.46175E-03	1.40000E+01	7.35565E-05
6.75000E+00	3.58317E-03	1.42500E+01	7.82497E-05
7.00000E+00	1.04615E-03	1.45000E+01	6.53464E-05
7.25000E+00	2.00213E-03	1.47500E+01	4.73491E-04
7.50000E+00	1.30473E-03	1.50000E+01	8.46809E-07

SPECTRAL DENSITY EDGE - Y AXIS



CDC 6600 CSP Printout II

Reference Program: Processing of TV data run no. 3

Tracking Program: Run number 82 using above referenced data

```
DIGITAL CORRELATION TRACKER  -  REFERENCING PROGRAM

 ROCESSING PICTURES
SEARCH WINDOW IS 16 X  16
STARTING TARGET COORDINATES ARE (43,42)
TAPE OUTPUT OPTION IS 1

CONTRAST .......NEG
```

COORDINATE ERROR ANALYSIS

STARTING COORDINATES * X= 42.00
Y= 43.00

****

NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR
1	0.00	0.00	2	1.44	-1.56	3	-1.63	-.81
4	-.94	-1.00	5	-.56	-1.81	6	-.06	-1.81
7	-.44	-2.31	8	-2.00	.94	9	-1.44	.31
10	-2.56	1.06	11	.63	.25	12	1.75	.31
13	.25	2.13	14	1.94	2.44	15	-1.31	-.25
16	-1.44	-2.88	17	.75	-3.69	18	2.38	.25
19	.94	1.13	20	-.56	-1.56	21	-1.88	-2.69
22	3.75	-.69	23	.50	-4.75	24	-.69	-2.06
25	-1.56	-1.25	26	-.50	-2.56	27	-2.38	-4.13
28	-1.00	-.81	29	-.56	-2.00	30	1.19	1.44
31	-1.38	.25	32	.31	-3.00	33	-1.19	-.38
34	1.81	-1.13	35	1.19	.25	36	-.25	-3.00
37	-.81	-4.94	38	-1.13	-5.13	39	-2.25	-2.69
40	2.44	-.81	41	2.69	-3.38	42	0.00	-2.88
43	3.13	.44	44	1.56	-1.94	45	3.13	-2.81
46	2.81	-2.13						

SIGNAL/NOISE DETERMINATION

S LE	SIGNAL LEVEL	NOISE LEVEL	S/N
1	14.15	4.68	3.03
2	14.65	4.56	3.21
3	14.93	7.42	2.01
4	14.62	7.24	2.02

RESULTANT SIGNAL/NOISE = 2.567

```
TRACKING RUN NO. 82

X DIMENSION = 16       Y DIMENSION = 16
X CENTER = 42          Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
  0 FRAMES SKIPPED.  49 FRAMES PROCESSED
FREQUENCY =  30.00
5 INPUT BITS USED
ICOLPS = 0      ICFF = 0
SCALOF =    4.00      SFACX =   5.00      SFACY =   5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD = SUM OF ABS VALUES
UPDATE AT  4 FRAMES(SKIP)
LINEAR PROCESSING ABOVE THRESHOLD OF = 22 FOR CENTROID TRACKER

CENTROID - X AXIS  GAIN =     .80440

CENTROID - Y AXIS  GAIN =     .80252

DIG CORR - X AXIS  GAIN =    1.00000

DIG CORR - Y AXIS  GAIN =    1.00000

EDGE - X AXIS      GAIN =     .63781

EDGE - Y AXIS      GAIN =     .94755
```

SAMPLE NO. 48   RUN NO. 82

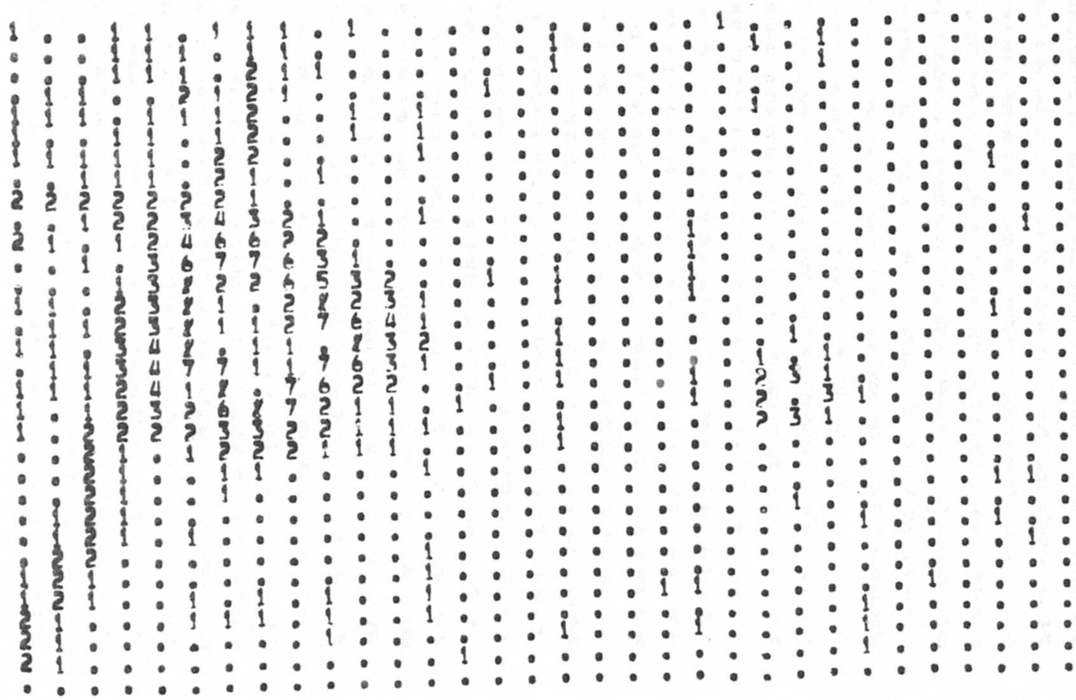
INPUT PICTURE (X OFFSET = -3, Y OFFSET = -3)

INPUT DATA DIVIDED BY 2

SAMPLE NO. 48 RUN NO. 82

VIDEO GRADIENTS

INPUT DATA DIVIDED BY 4



SAMPLE NO. 40   RUN NO. 02

EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

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. . . . 1 1 . . . . 1 1 . . . . . . . . . . . . . . . . . . . .
. . . . 1 1 1 . . 1 1 . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 48 RUN NO. 82

DCT TR. .KER INPLT DATA

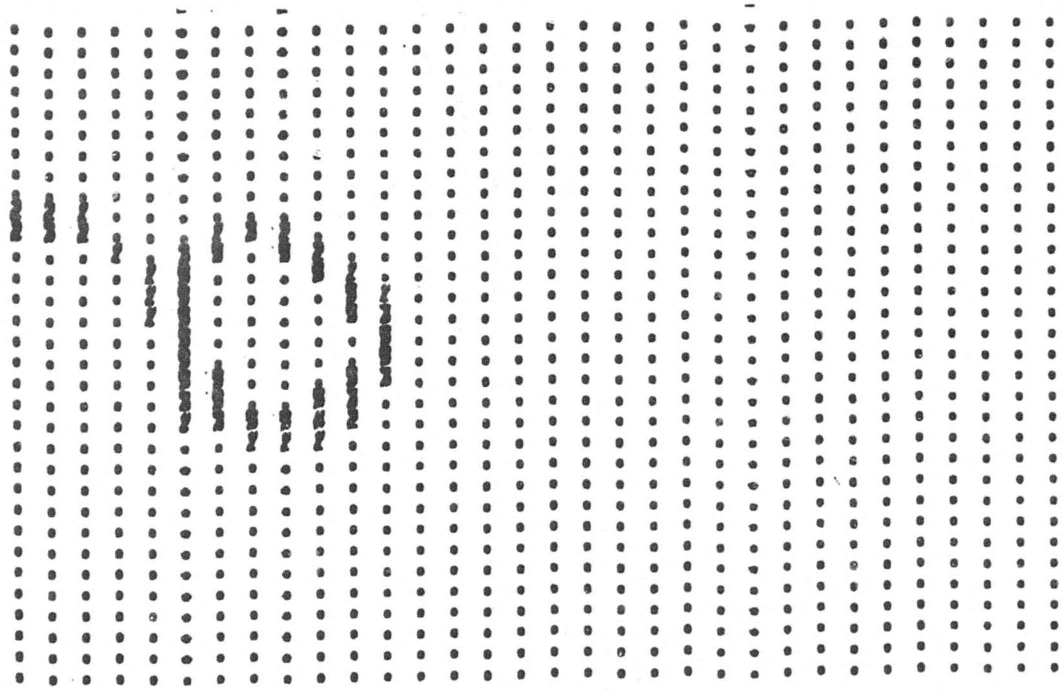
INPUT DATA DIVIDED BY 2

8	7	6	5	3	1	.	1	3	5	5	8	7	6	6	6	6	5	5	5	5	4	3	3	4	4	3	4	4	3	3	3
8	7	6	5	3	1	.	1	3	5	5	6	6	6	6	7	6	5	5	6	5	5	3	3	4	4	3	4	4	4	3	3
8	7	6	6	4	2	.	1	3	5	5	6	7	6	5	6	7	5	5	6	5	4	4	3	4	4	3	3	4	4	3	3
8	7	5	5	4	3	.	2	5	7	6	7	7	6	5	7	6	5	6	6	5	5	4	3	4	4	3	3	4	3	3	3
8	7	4	4	4	4	1	2	5	6	6	7	7	6	6	7	6	5	5	6	5	4	4	3	5	4	3	4	4	3	3	3
8	6	6	4	3	2	2	3	6	6	6	8	7	5	5	6	6	5	6	6	5	5	3	5	5	4	3	4	4	3	3	3
8	7	5	6	4	2	2	4	7	7	7	8	7	5	5	6	6	5	5	6	4	4	4	5	5	4	3	4	4	3	3	3
9	8	8	5	4	2	2	5	8	8	7	6	7	5	5	6	5	5	5	5	6	5	4	4	5	4	3	4	4	3	3	2
[illegible]	8	8	7	4	2	3	6	8	8	7	6	6	6	6	6	6	5	5	5	6	4	4	4	4	4	3	4	4	4	3	3
[illegible]	[illegible]	[illegible]	9	6	5	6	8	9	8	8	7	7	6	7	6	5	5	5	5	5	4	4	4	4	4	3	4	5	4	3	3
[illegible]	[illegible]	[illegible]	[illegible]	8	[illegible]	[illegible]	[illegible]	[illegible]	8	8	8	8	8	6	6	6	5	4	5	5	4	4	4	4	4	3	4	4	4	3	3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.	[illegible]	[illegible]	8	8	8	7	7	6	5	5	4	5	5	4	4	4	4	4	3	4	4	4	3	3
9	9	9	9	[illegible]	[illegible]	.	3	3	[illegible]	[illegible]	9	7	6	6	5	7	5	4	5	5	4	4	4	4	5	3	3	4	4	3	3
9	9	8	8	[illegible]	[illegible]	1	2	2	.	[illegible]	[illegible]	8	6	8	7	7	5	4	5	5	4	4	4	4	4	3	3	4	4	3	3
8	8	7	6	[illegible]	[illegible]	.	1	2	.	[illegible]	[illegible]	8	7	7	6	6	5	5	5	5	4	4	4	4	4	3	3	4	4	3	3
8	8	6	6	[illegible]	[illegible]	.	.	3	.	.	[illegible]	8	7	6	7	7	5	5	5	5	4	4	4	4	4	3	3	4	4	3	3
7	6	5	5	[illegible]	[illegible]	[illegible]	.	.	.	[illegible]	[illegible]	8	8	7	8	7	6	5	5	5	4	4	4	4	4	3	4	4	3	3	4
7	6	4	6	9	[illegible]	[illegible]	.	.	[illegible]	[illegible]	[illegible]	8	8	8	6	7	5	5	5	4	4	4	3	4	4	3	4	4	3	3	3
5	4	4	5	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	8	7	6	7	5	5	4	4	4	4	4	4	4	3	4	4	3	3	3
5	3	3	5	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	9	8	7	7	8	5	5	5	4	4	3	.	.	4	3	4	4	3	3	3
3	3	2	5	8	6	[illegible]	[illegible]	[illegible]	8	8	[illegible]	8	7	7	6	5	6	5	4	5	4	4	.	.	4	3	3	3	3	2	2
3	2	2	5	8	8	8	8	8	8	8	8	8	7	5	7	5	5	6	5	4	4	4	4	5	4	3	3	4	3	2	2
3	2	2	6	8	8	7	6	8	7	7	8	8	6	5	5	6	5	5	5	4	5	4	5	5	4	4	3	4	4	2	3
2	2	3	7	8	8	8	8	8	6	7	7	7	7	6	6	6	4	5	5	5	4	4	4	4	4	4	3	4	4	3	3
2	2	4	7	8	8	7	8	7	7	7	8	8	6	5	5	6	5	5	4	5	4	4	4	4	5	3	3	4	4	3	3
2	2	5	8	9	8	7	8	8	7	7	7	7	7	5	7	5	6	4	4	4	4	4	4	5	4	3	3	4	4	3	3
1	3	5	8	8	8	8	7	8	8	7	7	8	5	6	6	6	6	5	4	4	4	4	3	4	4	3	3	4	4	2	4
2	3	7	8	9	8	7	7	8	8	7	7	7	6	6	5	6	6	4	4	4	4	4	4	4	4	3	3	4	4	3	3
2	4	6	8	8	8	6	6	8	8	6	7	8	6	6	5	5	6	5	5	4	5	4	4	4	4	2	2	3	4	3	3
3	5	6	7	8	8	8	7	8	8	6	7	8	7	6	5	6	5	5	5	5	4	3	5	4	3	2	2	3	3	3	2
3	6	8	7	8	8	8	8	8	8	7	8	8	7	6	6	7	6	6	6	6	4	5	5	5	3	2	3	3	3	3	3
3	6	8	8	8	8	7	8	8	8	8	8	7	8	7	6	7	6	5	5	5	5	5	5	4	3	2	2	3	3	3	3

SAMPLE NO. #8 RUN NO. 82

CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2



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SAMPLE NO. 48     RUN NO. 82

CORREL..ION REFERENCE MATRIX

15 8 2 3 8 810121513121212121010
14 7 2 4 91010131413111212121111
13 6 2 4 81010121212111212121012
15 7 2 6111113121313121212111110
12 6 4 91313151316141313121 1 910
12 5 611171313161616151313121010
15 8 9152315161614151513121210 9
1813162223221917161513131311 910
18162321 3242621118161313151210 9
151726 0 1 324282217131313131110
141827 0 0 2 22426181514151512 9
121927 0 0 2 0 33021161615121110
101827 6 0 1 1 33024191615131110
10192927 0 0 0 93026201615131211
11172428 6 0 93028241917161312 12
1117212927 930292421171616141110

TRACKING ERRORS

EDGE ERRORS XM= -2.8264   YM= -2.7222     XC=  .6111   YC=  .7153
CENTROID ERRORS XM= -5.3728   YM= -2.5701     XC= -1.9353   YC=  .8674
CORRELATION ERRORS XM= -5.1592   YM= -4.2317     XC= -1.7217   YC= -.7938
FRAME OFFSETS   -3   -3     INPUT INCR. ERRORS       -.4375      -.4375
FINAL SEARCH CORRELATIONS =
7.30E+02   5.70E+02   9.58E+02   6.98E+02   5.72E+02   9.50E+02   9.20E+02   8.06E+02   1.17E+03
```

```
STATISTICAL DATA

                                RESOLUTION ELEMENTS                                      REGRESSION COEF
CENTROID - X AXIS          MEAN   -2.047576E+00       RMS     4.095808E-01       BETA    -8.876027E-04
CENTROID - Y AXIS          MEAN   -4.481478E-01       RMS     4.764689E-01       BETA     2.651491E-02
    RADIAL ERROR(RMS)=      .6283            DRIFT DISTANCE=   4.4465

DIG CORR - X AXIS          MEAN   -1.000737E+00       RMS     3.679164E-01       BETA    -5.358150E-02
DIG CORR - Y AXIS          MEAN   -6.434376E-01       RMS     2.176977E-01       BETA    -1.612146E-02
    RADIAL ERROR(RMS)=      .4275            DRIFT DISTANCE=   2.6858

EDGE - X AXIS              MEAN   -1.372266E+00       RMS     4.908897E-01       BETA    -7.747950E-02
EDGE - Y AXIS              MEAN   -2.077042E-01       RMS     3.077224E-01       BETA     1.349168E-02
    RADIAL ERROR(RMS)=      .5794            DRIFT DISTANCE=   3.7750
```

TRACKING ERRORS

CENTROID - X AXIS

.2238	.1753	-.2160	-.7779	-.4517	-.0577	-1.1685	-.5948	-1.2340	-.9799
-.7704	-.5977	-1.1207	-1.5298	-.0905	-2.2573	-.5776	-1.9915	-1.6945	-.9161
-1.0478	-1.6909	-2.1265	-1.3136	-2.3549	-1.4539	-2.1038	-2.0550	-1.6886	-2.3018
-2.3769	-2.8234	-2.8588	-2.7697	-3.8993	-4.2329	-4.0247	-2.8491	-2.6566	-3.2796
-4.4250	-4.2063	-4.4064	-3.5639	-3.6158	-4.9149	-2.3661	-3.2418		

CENTROID - Y AXIS

-.2144	-1.0532	-.4356	-.8271	-.9424	-.3467	-.7970	-.4777	-.4650	-1.2524
-.5009	-.6974	-.4634	-1.1287	-.7071	-2.1223	-.8701	-.8171	-.3665	-1.2899
-.4369	-.9783	-.6296	-1.7282	-1.0000	-1.6050	-1.0295	-.1243	-1.1597	-.2706
.8172	.4930	-.0783	.2143	-.8978	.2684	1.1353	-.6015	.1446	.5477
-.5219	-.7227	-.3933	.6483	.5334	-.0976	1.5366	.2349		

DIG CORR - X AXIS

.2970	.0460	.1326	-.2652	-.0140	-.4064	-.2391	-.1889	-.4540	-.3264
.3220	.0155	-.1036	-.3674	-.3808	-.4723	-.5143	-.3543	-.4269	-.7880
-.2031	-.4993	-.7337	-.5529	-.7328	-.7212	-1.5268	-1.4097	-.9405	-1.2187
-1.6611	-2.1314	-2.0745	-1.9413	-1.7085	-1.7271	-2.0461	-2.1242	-1.7423	-2.0587
-1.9497	-3.8106	-1.6927	-1.7613	-1.3298	-1.6601	-1.5676	-1.7217		

DIG CORR - Y AXIS

-.5396	-.6451	-.2388	.0042	-.2078	-.2466	-.1277	-.4195	-.1251	.0148
-.4784	-.6135	-.5357	-.4445	-.6815	-.7422	-.8624	-.7280	-.6563	-.5437
-.6998	-.6942	-.9571	-1.1688	-1.0995	-1.0177	-.5708	-.9250	-1.6195	-.8037
-.9399	-1.1409	-1.0965	-.7675	-.9131	-.9634	-1.0087	-.5729	-.7805	-.7211
-.7157	-.7257	-.5905	-.7227	-1.0569	-.8655	-1.0254	-.7938		

EDGE - X AXIS

.7675	1.6140	.3875	1.0690	-.1295	1.1568	-.0139	-.1139	-.7367	-.1556
-.5461	-.4083	-1.8598	-.7916	.3241	-.8597	-.1544	-1.5416	-.8442	-.7567
-.3765	-1.8936	-2.1762	-1.6534	-1.8377	-.9676	-1.5283	-1.6019	-1.4538	-1.6430
-1.9974	-2.0113	-1.7024	-2.0655	-2.2895	-3.0772	-3.4068	-3.0191	-2.5029	-3.4027
-4.0067	-1.8756	-2.4191	-2.7008	-2.7169	-2.2644	-2.2551	-.9939		

EDGE - Y AXIS

-.3247	-.4151	-.2785	-.2669	-.5489	-.2559	-.2389	-.2430	-.5173	-.3688
-.2485	-.0574	-.4480	-.7158	-.4841	-.8187	-.3461	-.5781	-.5355	-.5393
-.3110	-.9193	-.8788	-.9227	-.6792	-.2623	-.1941	.3379	.1877	-.0952
.3485	.3931	-.1598	.6649	.1297	-.1948	.4183	.4502	.4755	-.3798
-.2073	-.2406	-.1610	-.4867	.3715	-.2987	.4601	.5646		

FILTERED TRACKER DATA

CENTROID - X AXIS

0.0000	0.0000	.0018	-.3350	-.6058	-.4669	-.5665	-.7133	-.9940	-1.0954
-.9915	-.7391	-.7633	-1.1497	-.9798	-1.2476	-1.2204	-1.4752	-1.6654	-1.4987
-1.1275	-1.1639	-1.6828	-1.8475	-1.9813	-1.8366	-1.8538	-1.9515	-1.9364	-2.0158
-2.2170	-2.9763	-2.8489	-2.9095	-3.2605	-3.8669	-4.2437	-3.7707	-2.9513	-2.6998
-3.4395	-4.2483	-4.5947	-4.2046	-3.6892	-3.9451	-3.6633	-3.2090		

CENTROID - Y AXIS

0.0000	0.0000	-.5074	-.8593	-.9383	-.7233	-.6006	-.5328	-.5064	-.7668
-.8511	-.7765	-.5680	-.7007	-.8388	-1.3805	-1.4869	-1.1780	-.6123	-.6390
-.7219	-.8473	-.7847	-1.1077	-1.2876	-1.4493	-1.3233	-.7765	-.5846	-.5014
.0031	.5596	.5208	.2104	-.3595	-.3852	.3054	.4289	.1623	.1033
-.0195	-.3947	-.6354	-.1666	.4654	.5096	.7431	.7373		

DIG CORR - X AXIS

0.0000	0.0000	.1077	-.0008	-.1004	-.2499	-.3076	-.2759	-.3025	-.3485
-.1161	.1104	.1078	-.1508	-.3826	-.4925	-.5157	-.4550	-.4029	-.5328
-.5098	-.4486	-.5162	-.6144	-.6922	-.7210	-1.0411	-1.3859	-1.3590	-1.1808
-1.2807	-1.7427	-2.1276	-2.1708	-1.9270	-1.7064	-1.7688	-2.0011	-2.0230	-1.9764
-1.9404	-2.6644	-2.7682	-2.2541	-1.5003	-1.2957	-1.4429	-1.6676		

DIG CORR - Y AXIS

0.0000	0.0000	-.3655	-.3536	-.1719	-.1243	-.1577	-.2734	-.2772	-.1428
-.1772	-.4162	-.6095	-.5503	-.5660	-.6425	-.7868	-.8286	-.7521	-.6149
-.5863	-.6451	-.8068	-1.0275	-1.1608	-1.1339	-.8702	-.7360	-1.0605	-1.2158
-1.1004	-.9866	-1.0288	-.9792	-.8922	-.8781	-.9538	-.8508	-.7308	-.6782
-.7024	-.7261	-.6805	-.6618	-.7949	-.9186	-.9984	-.9354		

EDGE - X AXIS

0.0000	0.0000	.7344	1.1365	.6879	.5320	.3791	.1429	-.3718	-.5318
-.5106	-.4229	-.9726	-1.2782	-.7155	-.2871	-.1708	-.7524	-1.1277	-1.0892
-.6699	-.9238	-1.6937	-2.1083	-2.0207	-1.4805	-1.2185	-1.3314	-1.5245	-1.6255
-1.7820	-1.9655	-1.9446	-1.9228	-2.0655	-2.5670	-3.1667	-3.3696	-3.0086	-2.8910
-3.3722	-3.1519	-2.5473	-2.2667	-2.4943	-2.5792	-2.4120	-1.7453		

EDGE - Y AXIS

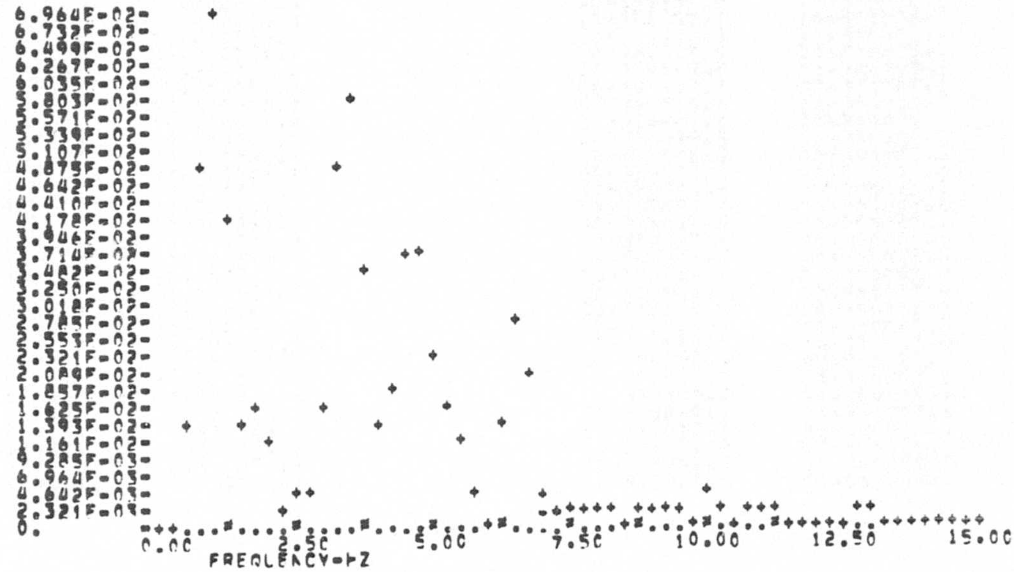
0.0000	0.0000	-.2759	-.3865	-.4350	-.3916	-.3017	-.2238	-.3178	-.4166
-.3862	-.2071	-.2011	-.4477	-.6234	-.7300	-.6090	-.5099	-.4825	-.5245
-.4629	-.5835	-.7960	-.9584	-.8841	-.5664	-.2441	.0993	.2760	.1764
.1307	.2467	.1879	.2787	.3015	.1218	.0830	.2684	.4854	.2191
-.1722	-.3708	-.2952	-.2957	-.0768	-.0163	.1603	.3958		

SPECTRAL DENSITY CENTROID - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	9.18848E-04
5.00000E-01	1.39604E-02
7.50000E-01	4.94772E-02
1.00000E+00	6.96363E-02
1.25000E+00	4.16092E-02
1.50000E+00	1.42694E-02
1.75000E+00	1.53523E-02
2.00000E+00	1.08278E-02
2.25000E+00	2.45139E-03
2.50000E+00	3.58256E-03
2.75000E+00	3.76723E-03
3.00000E+00	1.71798E-02
3.25000E+00	4.79305E-02
3.50000E+00	5.77701E-02
3.75000E+00	3.50301E-02
4.00000E+00	1.39715E-02
4.25000E+00	1.92973E-02
4.50000E+00	3.65691E-02
4.75000E+00	3.64909E-02
5.00000E+00	2.22298E-02
5.25000E+00	1.54669E-02
5.50000E+00	1.24275E-02
5.75000E+00	4.41032E-03
6.00000E+00	8.97669E-04
6.25000E+00	1.29586E-02
6.50000E+00	2.78294E-02
6.75000E+00	2.05689E-02
7.00000E+00	5.02097E-03
7.25000E+00	3.33253E-03
7.50000E+00	2.80198E-03
7.75000E+00	1.32937E-03
8.00000E+00	3.09543E-03
8.25000E+00	1.17107E-03
8.50000E+00	1.02026E-03
8.75000E+00	1.97507E-03
9.00000E+00	1.54857E-03
9.25000E+00	3.46414E-03
9.50000E+00	1.59713E-03
9.75000E+00	6.88829E-04
1.00000E+01	4.44946E-03
1.02500E+01	2.88921E-03
1.05000E+01	3.54596E-04
1.07500E+01	1.63060E-03
1.10000E+01	2.02039E-03
1.12500E+01	1.77755E-03
1.15000E+01	1.09683E-03
1.17500E+01	7.32101E-04
1.20000E+01	1.03227E-03
1.22500E+01	2.41579E-04
1.25000E+01	5.88851E-04
1.27500E+01	2.09846E-03
1.30000E+01	1.41560E-03
1.32500E+01	1.16559E-04
1.35000E+01	7.71536E-04
1.37500E+01	1.07187E-03
1.40000E+01	1.44407E-04
1.42500E+01	2.03213E-04
1.45000E+01	5.42522E-04
1.47500E+01	3.32984E-04
1.50000E+01	2.65577E-04

SPECTRAL DENSITY CENTROID - X AXIS

AMPLIT' - UNITS**2/HZ

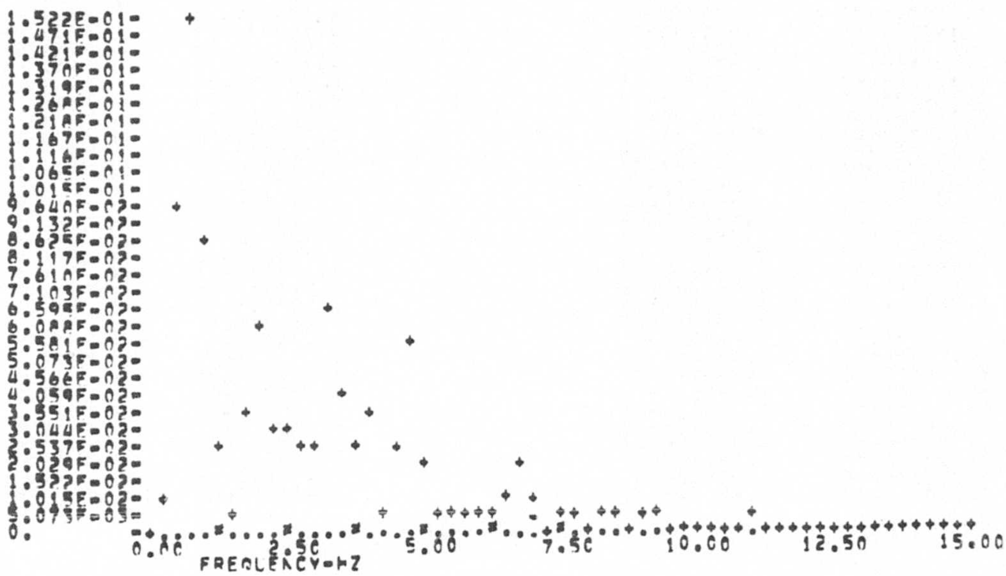


SPECTRAL DENSITY CENTROID - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.19630E-02	7.75000E+00	4.50003E-03
5.00000E-01	9.78218E-02	8.00000E+00	1.90065E-04
7.50000E-01	1.52203E-01	8.25000E+00	4.32468E-03
1.00000E+00	8.61460E-02	8.50000E+00	5.29038E-03
1.25000E+00	2.71548E-02	8.75000E+00	2.88156E-05
1.50000E+00	5.80443E-03	9.00000E+00	4.08492E-03
1.75000E+00	3.51636E-02	9.25000E+00	4.18360E-03
2.00000E+00	6.21874E-02	9.50000E+00	1.36102E-03
2.25000E+00	3.14941E-02	9.75000E+00	2.24560E-03
2.50000E+00	2.92048E-02	1.00000E+01	6.00164E-04
2.75000E+00	2.35281E-02	1.02500E+01	5.93322E-04
3.00000E+00	2.70743E-02	1.05000E+01	1.24890E-04
3.25000E+00	6.60209E-02	1.07500E+01	1.33102E-03
3.50000E+00	3.99156E-02	1.10000E+01	3.37288E-03
3.75000E+00	2.48861E-02	1.12500E+01	6.14440E-04
4.00000E+00	3.71245E-02	1.15000E+01	6.55318E-04
4.25000E+00	5.13614E-03	1.17500E+01	1.04220E-03
4.50000E+00	2.41303E-02	1.20000E+01	2.36869E-05
4.75000E+00	5.40856E-02	1.22500E+01	1.09657E-03
5.00000E+00	2.27315E-02	1.25000E+01	5.52492E-04
5.25000E+00	5.99927E-03	1.27500E+01	2.62643E-04
5.50000E+00	7.13297E-03	1.30000E+01	2.80296E-04
5.75000E+00	6.80689E-03	1.32500E+01	1.96748E-04
6.00000E+00	7.14808E-03	1.35000E+01	9.99294E-04
6.25000E+00	3.54594E-03	1.37500E+01	4.81231E-04
6.50000E+00	1.76485E-02	1.40000E+01	1.07266E-05
6.75000E+00	1.91919E-02	1.42500E+01	4.16145E-05
7.00000E+00	9.19669E-03	1.45000E+01	6.52982E-04
7.25000E+00	3.64139E-04	1.47500E+01	1.14767E-03
7.50000E+00	2.74430E-03	1.50000E+01	8.46571E-04

SPECTRAL DENSITY CENTROID = Y AXIS

AMPLIT = UNITS**2/HZ



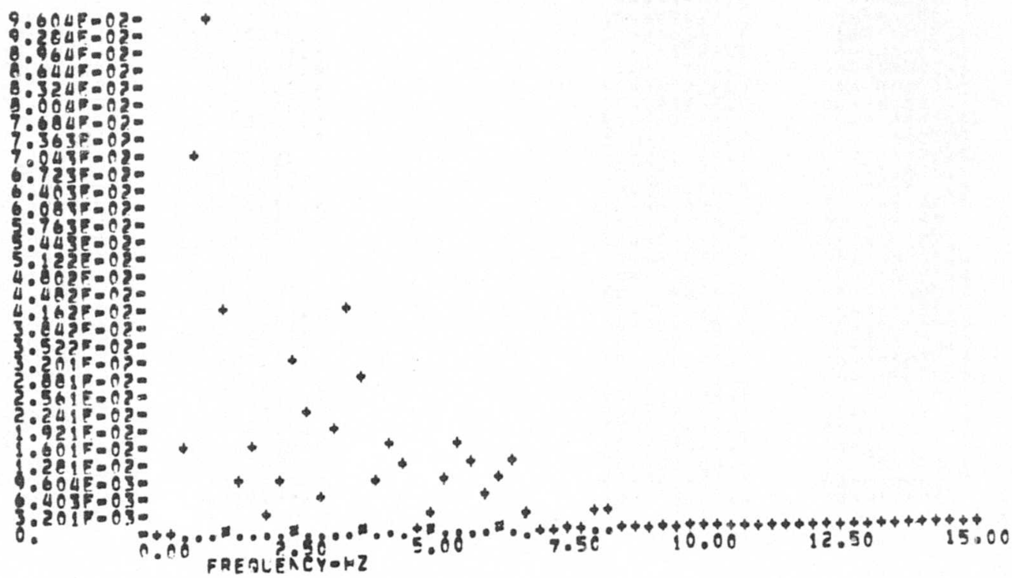
SPECTRAL DENSITY DIG CORR - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	4.14603E-04
5.00000E-01	1.50905E-02
7.50000E-01	6.94574E-02
1.00000E+00	9.60447E-02
1.25000E+00	4.17503E-02
1.50000E+00	9.55184E-03
1.75000E+00	1.57238E-02
2.00000E+00	2.36375E-03
2.25000E+00	8.74036E-03
2.50000E+00	3.10154E-02
2.75000E+00	2.39498E-02
3.00000E+00	7.66681E-03
3.25000E+00	1.89561E-02
3.50000E+00	4.14831E-02
3.75000E+00	2.87642E-02
4.00000E+00	8.20576E-03
4.25000E+00	1.51727E-02
4.50000E+00	1.26304E-02
4.75000E+00	7.05693E-04
5.00000E+00	3.13348E-03
5.25000E+00	9.46859E-03
5.50000E+00	1.48121E-02
5.75000E+00	1.24694E-02
6.00000E+00	6.76903E-03
6.25000E+00	1.12006E-02
6.50000E+00	1.26143E-02
6.75000E+00	4.71269E-03
7.00000E+00	1.58091E-04
7.25000E+00	5.50946E-04
7.50000E+00	2.62024E-04

FREQ - HZ	AMP - UNITS**2/HZ
7.75000E+00	2.79290E-04
8.00000E+00	1.84660E-03
8.25000E+00	1.87686E-03
8.50000E+00	1.26790E-03
8.75000E+00	8.10531E-04
9.00000E+00	6.21493E-05
9.25000E+00	7.76475E-04
9.50000E+00	6.80148E-04
9.75000E+00	3.21394E-05
1.00000E+01	5.54354E-04
1.02500E+01	2.25612E-04
1.05000E+01	6.44320E-05
1.07500E+01	2.09161E-04
1.10000E+01	6.57934E-05
1.12500E+01	2.22010E-04
1.15000E+01	6.96344E-05
1.17500E+01	9.12661E-05
1.20000E+01	1.91477E-04
1.22500E+01	2.68288E-04
1.25000E+01	4.69338E-04
1.27500E+01	3.18855E-04
1.30000E+01	2.52847E-04
1.32500E+01	4.41879E-04
1.35000E+01	1.98778E-04
1.37500E+01	4.20893E-04
1.40000E+01	3.76983E-04
1.42500E+01	6.57838E-05
1.45000E+01	8.36007E-05
1.47500E+01	6.42433E-05
1.50000E+01	3.02274E-05

SPECTRAL DENSITY DIG CORR - X AXIS

AMPLIT' = UNITS**2/HZ

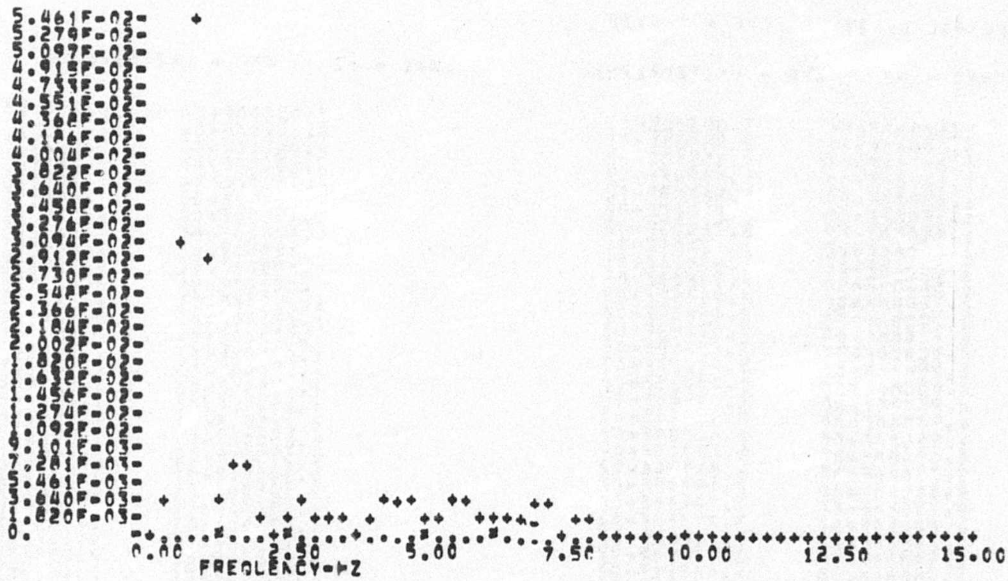


SPECTRAL DENSITY DIG CORR - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	3.57585E-03	7.75000E+00	9.22070E-04
5.00000E-01	3.16299E-02	8.00000E+00	1.04132E-03
7.50000E-01	5.46060E-02	8.25000E+00	2.79325E-04
1.00000E+00	2.89780E-02	8.50000E+00	8.61642E-06
1.25000E+00	3.46737E-03	8.75000E+00	2.55623E-04
1.50000E+00	6.91991E-03	9.00000E+00	9.01617E-04
1.75000E+00	7.76702E-03	9.25000E+00	4.89944E-04
2.00000E+00	1.80496E-03	9.50000E+00	3.93779E-05
2.25000E+00	9.98718E-05	9.75000E+00	2.55727E-04
2.50000E+00	1.77400E-03	1.00000E+01	1.84683E-04
2.75000E+00	3.39728E-03	1.02500E+01	3.05647E-04
3.00000E+00	2.47117E-03	1.05000E+01	2.57268E-04
3.25000E+00	1.55209E-03	1.07500E+01	2.28902E-05
3.50000E+00	1.57682E-03	1.10000E+01	6.82369E-05
3.75000E+00	8.41289E-04	1.12500E+01	6.65483E-05
4.00000E+00	9.85209E-04	1.15000E+01	1.73090E-04
4.25000E+00	2.77588E-03	1.17500E+01	1.30414E-04
4.50000E+00	3.89991E-03	1.20000E+01	4.77849E-06
4.75000E+00	2.94887E-03	1.22500E+01	7.31193E-05
5.00000E+00	1.62414E-03	1.25000E+01	1.71808E-05
5.25000E+00	2.39372E-03	1.27500E+01	2.93365E-05
5.50000E+00	4.38445E-03	1.30000E+01	6.60979E-05
5.75000E+00	3.63263E-03	1.32500E+01	2.72950E-05
6.00000E+00	1.29813E-03	1.35000E+01	3.73099E-05
6.25000E+00	1.27998E-03	1.37500E+01	5.10571E-06
6.50000E+00	1.28875E-03	1.40000E+01	1.44994E-05
6.75000E+00	1.94492E-03	1.42500E+01	1.21231E-05
7.00000E+00	4.45380E-03	1.45000E+01	2.69831E-05
7.25000E+00	3.15614E-03	1.47500E+01	9.43890E-05
7.50000E+00	4.44128E-04	1.50000E+01	1.07784E-04

SPECTRAL DENSITY DIG CORR - Y AXIS

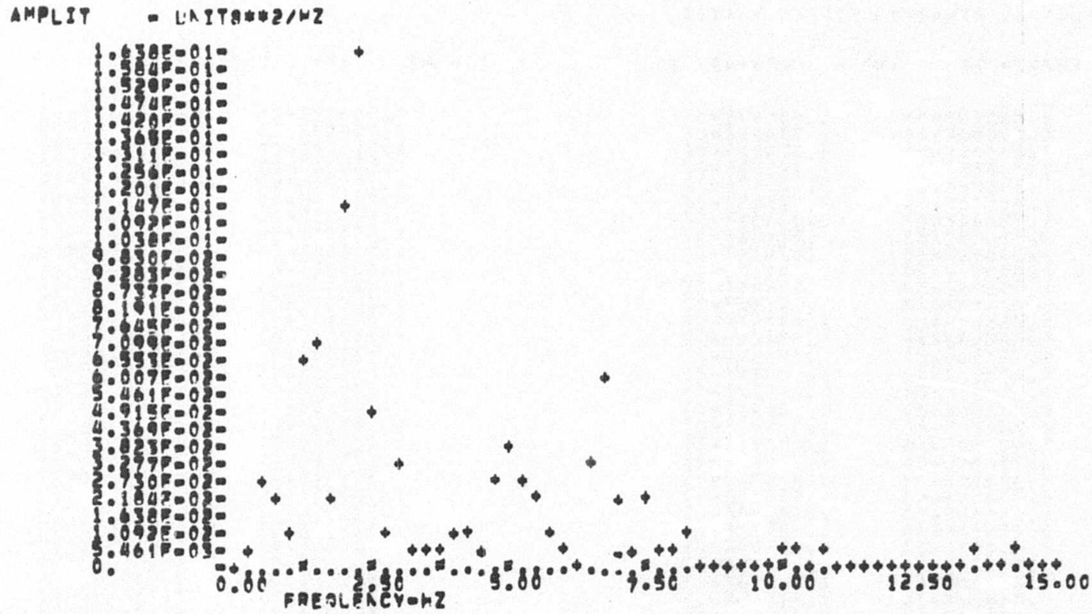
AMPLITUDE = UNITS**2/HZ



SPECTRAL DENSITY EDGE - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	3.45305E-03
5.00000E-01	2.49536E-02
7.50000E-01	2.39315E-02
1.00000E+00	1.07745E-02
1.25000E+00	6.56708E-02
1.50000E+00	7.21820E-02
1.75000E+00	2.36383E-02
2.00000E+00	1.12051E-01
2.25000E+00	1.63826E-01
2.50000E+00	4.79822E-02
2.75000E+00	8.21057E-03
3.00000E+00	3.15638E-02
3.25000E+00	7.07453E-03
3.50000E+00	3.53618E-03
3.75000E+00	7.31228E-03
4.00000E+00	1.03425E-02
4.25000E+00	1.12548E-02
4.50000E+00	2.91528E-03
4.75000E+00	2.54200E-02
5.00000E+00	3.67260E-02
5.25000E+00	2.54704E-02
5.50000E+00	2.19089E-02
5.75000E+00	1.12980E-02
6.00000E+00	3.27350E-03
6.25000E+00	2.71969E-03
6.50000E+00	3.37090E-02
6.75000E+00	6.08861E-02
7.00000E+00	2.04501E-02
7.25000E+00	3.02214E-03
7.50000E+00	2.22673E-02
7.75000E+00	6.89182E-03
8.00000E+00	3.05627E-03
8.25000E+00	9.84355E-03
8.50000E+00	1.33580E-03
8.75000E+00	1.74497E-03
9.00000E+00	1.28408E-03
9.25000E+00	4.34883E-04
9.50000E+00	1.23172E-03
9.75000E+00	2.82096E-04
1.00000E+01	4.80219E-03
1.02500E+01	3.23165E-03
1.05000E+01	4.45383E-04
1.07500E+01	2.88248E-03
1.10000E+01	2.02157E-03
1.12500E+01	1.66152E-03
1.15000E+01	1.50533E-03
1.17500E+01	1.51102E-03
1.20000E+01	1.25066E-03
1.22500E+01	7.85805E-04
1.25000E+01	1.75005E-03
1.27500E+01	1.62437E-03
1.30000E+01	3.48835E-04
1.32500E+01	8.29272E-04
1.35000E+01	3.04022E-03
1.37500E+01	2.15913E-03
1.40000E+01	4.11207E-04
1.42500E+01	2.88024E-03
1.45000E+01	2.17188E-03
1.47500E+01	1.04637E-03
1.50000E+01	2.60477E-03

SPECTRAL DENSITY EDGE - X AXIS

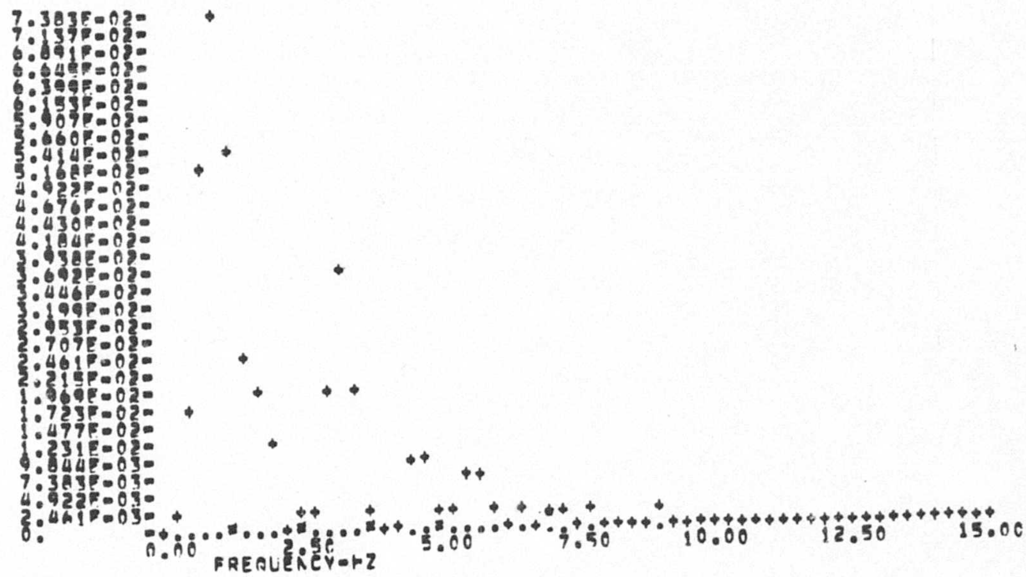


SPECTRAL DENSITY EDGE - Y AXIS

FREG - HZ	AMP - UNITS**2/HZ	FREG - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.52187E-03	7.75000E+00	1.42518E-03
5.00000E-01	1.77421E-02	8.00000E+00	1.06099E-03
7.50000E-01	5.27422E-02	8.25000E+00	2.06083E-05
1.00000E+00	7.38322E-02	8.50000E+00	3.51181E-04
1.25000E+00	5.30075E-02	8.75000E+00	8.60892E-04
1.50000E+00	2.42563E-02	9.00000E+00	1.26775E-03
1.75000E+00	2.02332E-02	9.25000E+00	2.66013E-04
2.00000E+00	1.22446E-02	9.50000E+00	3.64928E-04
2.25000E+00	5.43919E-04	9.75000E+00	6.73360E-04
2.50000E+00	1.44117E-03	1.00000E+01	8.63651E-06
2.75000E+00	1.73991E-03	1.02500E+01	3.08575E-04
3.00000E+00	1.84783E-02	1.05000E+01	5.16681E-05
3.25000E+00	3.61802E-02	1.07500E+01	4.94700E-04
3.50000E+00	1.88047E-02	1.10000E+01	1.05204E-03
3.75000E+00	1.49039E-03	1.12500E+01	1.91956E-04
4.00000E+00	2.14989E-04	1.15000E+01	3.36617E-04
4.25000E+00	1.19504E-03	1.17500E+01	2.79311E-04
4.50000E+00	9.54641E-03	1.20000E+01	2.35392E-05
4.75000E+00	1.01342E-02	1.22500E+01	2.38091E-04
5.00000E+00	1.40251E-03	1.25000E+01	8.69063E-06
5.25000E+00	1.38064E-03	1.27500E+01	3.23186E-04
5.50000E+00	6.67972E-03	1.30000E+01	2.12294E-04
5.75000E+00	7.55077E-03	1.32500E+01	7.92049E-05
6.00000E+00	2.40268E-03	1.35000E+01	5.75505E-04
6.25000E+00	1.02977E-04	1.37500E+01	2.65989E-04
6.50000E+00	1.64124E-03	1.40000E+01	1.27191E-05
6.75000E+00	1.17538E-03	1.42500E+01	4.45903E-05
7.00000E+00	2.20996E-03	1.45000E+01	7.05341E-06
7.25000E+00	1.71543E-03	1.47500E+01	7.52264E-05
7.50000E+00	2.82618E-04	1.50000E+01	4.25807E-05

SPECTRAL DENSITY EDGE = Y AXIS

AMPLITUDE = UNITS**2/HZ



CDC 6600 CSP Printout III

Reference Program: Processing of TV data run no. 1 (same frames of imagery as data run no. 4 shown in Appendix IV)

Tracking Program: Run no. 84 using above referenced data

```
DIGITAL CORRELATION TRACKER  -  REFERENCING PROGRAM

PROCESS 101 PICTURES
SEARCH WINDOW IS 16 X  16
STARTING TARGET COORDINATES ARE (42,42)
TAPE OUTPUT OPTION IS 1

CONTRAST ......NEG
```

COORDINATE ERROR ANALYSIS

STARTI COORDINATES * X= 42.00
Y= 42.00

****

NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR
1	0.00	0.00	2	3.75	1.50	3	2.31	1.19
4	1.44	-.44	5	4.00	-3.69	6	2.56	-4.50
7	7.13	-.63	8	3.50	-.94	9	8.19	-4.19
10	4.44	-3.06	11	6.13	-.88	12	1.38	-2.31
13	5.69	-3.25	14	6.06	-1.38	15	8.75	-3.63
16	5.06	-2.00	17	5.81	-1.13	18	3.50	-.69
19	6.06	-3.38	20	7.25	-1.13	21	7.56	-3.19
22	7.13	-1.88	23	7.31	-1.13	24	6.75	-3.69
25	7.88	-3.94	26	6.50	-1.88	27	5.38	-3.06
28	7.94	-2.13	29	6.25	-2.75	30	6.94	-.50
31	7.50	-2.19	32	7.44	-1.44	33	5.56	.25
34	6.69	-1.25	35	6.06	-1.88	36	-10.50	-3.56
37	-5.94	-3.63	38	-5.81	-4.19	39	-8.50	-1.88
40	-7.06	-2.75	41	8.31	-.88	42	7.00	-1.13
43	6.69	-3.38	44	8.38	-2.88	45	7.25	-2.44
46	8.13	-.94	47	8.00	-3.88	48	8.81	-.50
49	7.56	-1.50	50	8.13	-1.38	51	7.56	-2.19
52	7.19	.50	53	7.69	-2.81	54	8.50	-2.25
55	7.63	1.06	56	5.75	.13	57	6.69	-1.44
58	4.06	-4.38	59	4.31	-3.44	60	4.94	-6.88
61	6.56	-3.94	62	6.44	-1.63	63	8.13	-2.19
64	8.44	-4.06	65	8.81	-4.38	66	9.06	-5.00
67	8.31	-5.69	68	8.75	-2.88	69	7.13	-5.19
70	7.06	-3.44	71	9.63	-1.94	72	9.06	-4.56
73	10.25	-4.19	74	10.50	-4.44	75	7.88	-6.81
76	9.75	-4.38	77	-7.50	-3.13	78	-7.00	-4.56
79	-5.31	-4.44	80	-6.69	-5.63	81	-7.81	-2.13
82	-11.12	-2.44	83	7.31	-3.81	84	7.94	-4.06
85	10.06	-3.81	86	10.12	-4.50	87	4.00	-6.31
88	6.50	-2.75	89	6.44	-4.13	90	4.31	-2.69
91	7.63	-3.81	92	9.00	-2.56	93	8.38	-2.31
94	9.88	-4.75	95	6.50	-5.94			

SIGNAL/NOISE DETERMINATION

SAMPLE	SIGNAL LEVEL	NOISE LEVEL	S/N
1	9.25	4.27	2.17
2	13.39	5.24	2.56
3	20.24	5.39	3.76
4	18.83	6.79	2.77
5	20.87	6.65	3.14
6	21.83	5.23	4.17
7	21.90	5.83	3.76
8	22.12	5.15	4.29
9	21.17	5.19	4.08

RESULTANT SIGNAL/NOISE = 3.410

```
TRACKING RUN NO. 84

X DIMENSION = 16        Y DIMENSION = 16
X CENTER = 32           Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
  0 FRAMES SKIPPED.  97 FRAMES PROCESSED
FREQUENCY =  30.00
5 INPUT BITS USED
ICOLPS = 0       ICFF = 0
SCALOF =    4.00        SFACX =    5.00       SFACY =    5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD = SUM OF ABS VALUES
UPDATE AT 10 FRAMES(SKIP)
LINEAR PROCESSING ABOVE THRESHOLD OF = 30 FOR CENTROID TRACKER

CENTROID - X AXIS   GAIN =      .60405

CENTROID - Y AXIS   GAIN =      .91265

DIG CORR - X AXIS   GAIN =     1.00000

DIG CORR - Y AXIS   GAIN =     1.00000

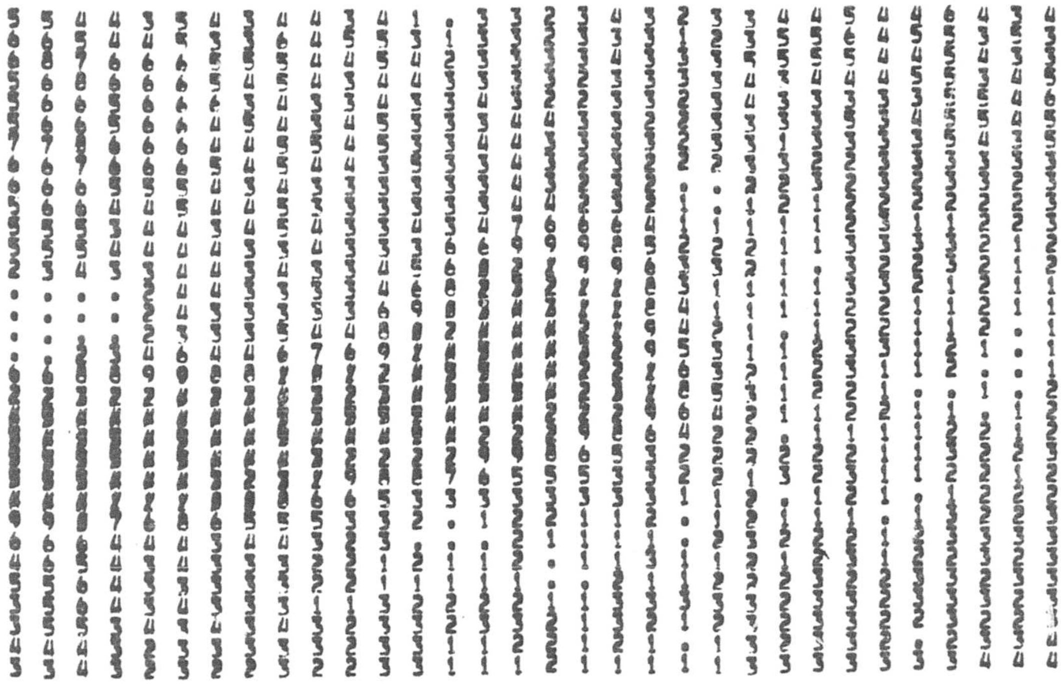
EDGE - X AXIS       GAIN =      .45104

EDGE - Y AXIS       GAIN =      .73560
```

SAMPLE NO. 96 RUN NO. 24

INPUT PICTURE (X OFFSET = -1, Y OFFSET = -2)

INPUT DATA DIVIDED BY 2



SAMPLE NO. 96   RUN NO. 84

VIDEO GRADIENTS

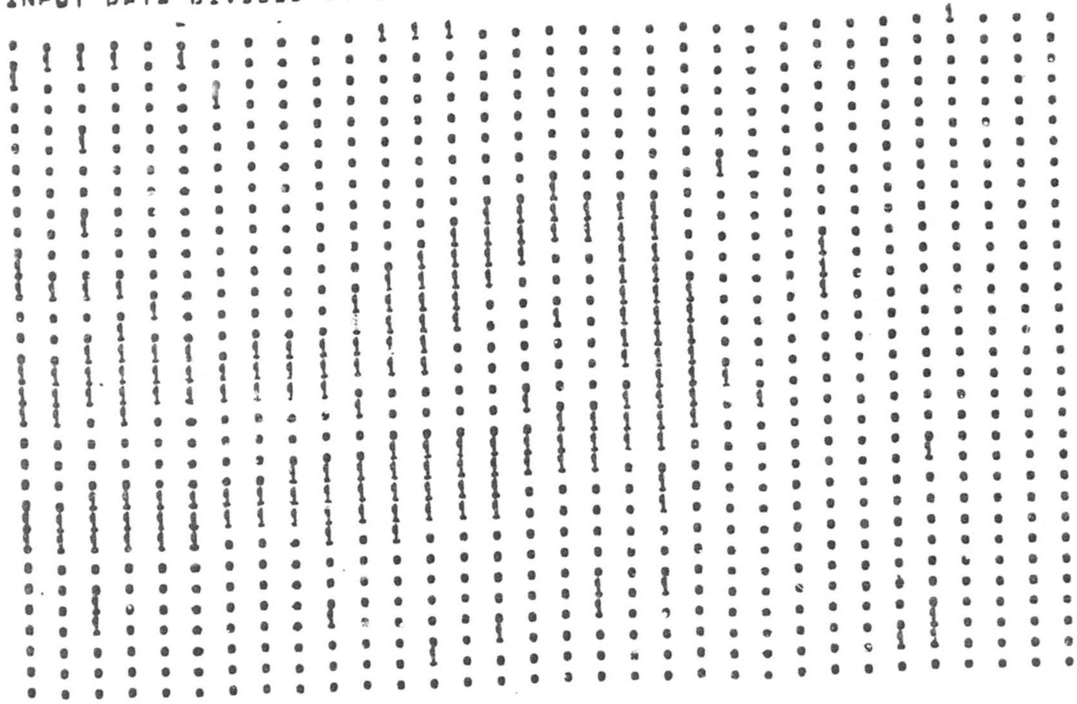
INPUT DATA DIVIDED BY 2

[illegible]

SAMPLE NO. 96   RUN NO. 84

EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1



SAMPLE NO. 96 RUN NO. 24

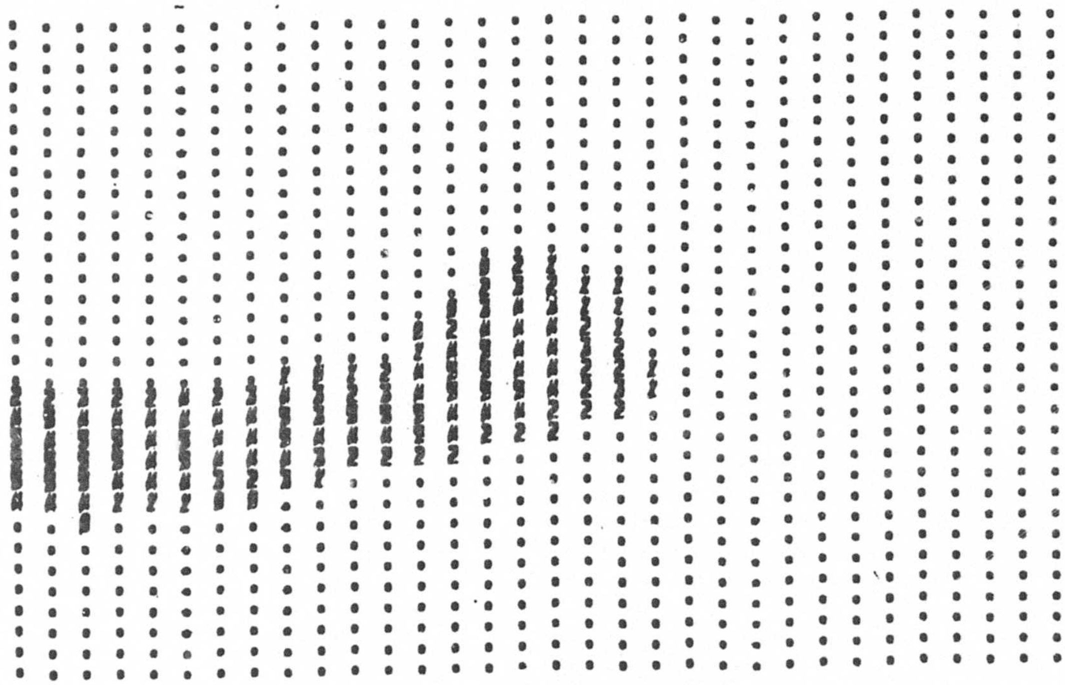
DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

SAMPLE NO. 96   RUN NO. 84

CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2



SAMPLE NO. 96   FLM NO. 84

CORREL..ION REFERENCE MATRIX

```
  8  6  5  5  3  0  0  0  0  1  2  2  2  1  4  4
  9  7  6  6  6  6  5  4  2  1  1  1  1  0  2  2
  9  6  6  8  9 10 12 13 10  5  4  2  1  0  0  1
  9  7  7  9 12 15 17 19 16  9  5  4  1  1  1  2
  7  7  7 10 15 19 21 23 21 14  9  6  2  2  2  2
  9  9  9 15 20 24 25 25 23 19 13  9  5  5  5  5
  9 10 12 16 24 26 26 26 24 21 15 11  8  5  4  5
 11 11 14 16 20 26 28 28 28 25 22 17 13  8  4  7
 14 16 21 27 30 31 30 28 27 23 20 16 10  6  6  9
 21 22 23 28 30 31 30 30 29 25 22 19 12  7  8  7
 28 28 28 30 30 30 29 29 30 27 23 19 13  9  8  8
 30 30 30 30 30 30 30 28 28 24 22 19 12  8  8  7
 30 30 29 28 28 27 26 23 21 19 18 16 10  7  6  6
 29 26 25 24 24 22 18 16 15 11 11 10  7  6  6  5
 24 21 18 17 16 13 11 12 10  7  6  5  5  5  6  6
 15 14 10  8  9  7  6  6  6  5  4  4  3  4  6  5
```

TRACKING ERRORS

EDGE ERRORS XM= 3.1852   YM= 2.0648   XC= 4.0602   YC= 1.5648

CENTROID ERRORS XM= 1.1163   YM= .7913   XC= 1.5913   YC= .2913

CORRELATION ERRORS XM= .5470   YM= -.0443   XC= 1.4220   YC= -.5442

FRAME OFFSETS -1 -0   INPUT INCR. ERRORS   .1250   .5000

FINAL SEARCH CORRELATIONS =
1.42E+03   1.03E+03   8.68E+02   1.08E+03   6.80E+02   6.86E+02   1.37E+03   1.09E+03   1.01E+03

```
STATISTICAL DATA

                         RESOLUTION ELEMENTS                                  REGRESSION COEF

CENTROID - X AXIS      MEAN    2.651861E+00     RMS    7.054840E-01     BETA    2.753699E-02

CENTROID - Y AXIS      MEAN    1.986863E-01     RMS    3.540826E-01     BETA    4.089553E-03
    RADIAL ERROR(RMS)=   .7894          DRIFT DISTANCE=  2.6720

DIG CORR - X AXIS      MEAN    1.552712E+00     RMS    3.729896E-01     BETA    1.397284E-02

DIG CORR - Y AXIS      MEAN   -7.139440E-02     RMS    3.692458E-01     BETA   -8.234586E-03
    RADIAL ERROR(RMS)=   .5248          DRIFT DISTANCE=  1.5570

EDGE - X AXIS          MEAN    6.468547E+00     RMS    1.935294E+00     BETA    8.085498E-02

EDGE - Y AXIS          MEAN    1.688545E+00     RMS    8.841406E-01     BETA    2.483952E-02
    RADIAL ERROR(RMS)=  2.1277          DRIFT DISTANCE=  8.1201
```

TRACKING ERRORS

CENTROID - X AXIS

-.7312	-.2321	-.7149	.6174	.0671	-.1518	.8038	.9579	.4196	.6771
1.9681	1.2502	1.8667	.8506	.5390	.8488	1.7885	2.1365	2.1921	1.4605
2.3368	2.7008	1.8653	3.8500	2.5578	3.0429	2.0758	2.4831	2.4493	2.3753
2.6507	2.6043	2.3428	2.6403	1.8568	3.2005	3.1785	3.3424	3.0641	3.2466
3.9835	3.2743	3.6499	3.4050	3.3476	3.0460	3.4047	2.9608	3.6702	2.6555
3.1089	3.6666	3.6797	2.8194	3.8121	3.4467	3.4211	3.5577	3.1834	3.2204
2.3646	2.6021	3.2285	3.4472	3.1827	3.0531	3.4343	2.9922	3.3363	3.1416
2.9387	3.4096	2.8866	2.2587	4.8390	3.2850	3.2190	3.6783	3.0719	3.1155
3.2217	3.4592	3.3265	3.2567	3.1037	4.5628	2.8669	3.8747	3.2595	3.1373
3.3489	4.4428	2.1795	1.9330	2.4126	2.7230				

CENTROID - Y AXIS

-.2407	-.2627	-1.4298	1.2101	-.2274	.6073	.7110	-1.4011	2.0816	-.0473
-.6789	-1.2492	.6107	.1848	1.2617	.5604	.3406	-.3514	.4433	.5776
-.0334	.4249	.7545	.1835	.4004	-.2449	.8945	-.1727	-.5815	-.2464
.4182	.1008	.0649	-.0477	.1158	.2635	-.1864	-.3291	-.1944	.2103
.1757	.5495	.1353	.1265	-.6073	.3168	-.5666	-.5845	-.5989	.4304
-.1149	-.4436	-.5402	.9700	.5592	.0884	.0742	.4711	.4122	-.4356
.7868	.5772	.4544	.7695	.3792	.1326	.3846	-.1130	.1622	.6295
.3299	-.1260	1.0233	.9510	-.4627	.8920	.0517	.5382	-.4322	.5713
-.1466	.2040	.7565	.1663	.7638	.2135	.7178	.0592	-.3306	.9225
.1380	-.3860	.9537	1.4152	.6616	.3670				

DIG CORR - X AXIS

-.7441	-.4457	-.2491	.0034	-.0829	.2559	.7588	.7179	1.1443	1.2086
1.3791	.5065	1.3235	1.0123	1.1725	1.4873	1.3107	1.3625	1.3700	1.4492
1.3233	2.0537	1.7791	1.8436	1.5769	2.0801	1.2297	1.1327	1.1840	1.2895
1.6090	.9985	1.0344	1.3061	.9119	1.3071	1.5128	1.8712	1.4883	2.0457
1.8695	1.5581	2.3512	2.0506	1.9410	1.8155	1.1801	1.6398	1.4605	1.4524
1.7213	1.6604	1.7973	1.3783	1.6376	1.8640	1.6655	2.0287	1.6360	1.9765
2.1455	2.1093	1.9690	1.7238	1.6470	1.8354	2.0445	2.0770	2.1806	1.8431
1.8620	2.1310	1.7631	1.8142	2.0137	1.6086	1.3158	1.8685	2.1225	1.8885
1.7681	1.5110	1.7885	1.9020	1.8866	2.0323	2.0984	2.0865	2.0501	1.8039
1.9971	2.4025	2.0619	1.7387	1.5456	1.4220				

DIG CORR - Y AXIS

.3717	-.0710	.0328	.3389	-.0898	.1759	-.0062	-.1341	.3610	-.0682
-3.3236	1.3968	.4929	-2.5571	.5080	.4219	.6906	-.3140	.3071	-.0780
.7978	.1119	1.0358	.4068	.3381	.7317	.7420	.1427	.4024	.6533
.8168	.2100	.6852	.4613	.0108	-.3313	-.1329	.5836	.3483	.1436
.1381	-.1461	-.7719	-.3366	-.1362	.0244	.0740	-.1853	.0156	-.0309
-.1564	.3300	.0702	-.0403	-.0101	-.0968	-.0725	.3855	.3522	.0714
.1187	-.1875	.4572	.1569	.1381	-.0536	.3061	.1620	-.4375	-.1249
-.4421	-.4349	-.1808	-.2871	-.0923	-.2674	-.4707	-.4603	-.5222	-.5675
-.7527	-.7340	-.7177	-.6850	-.6001	-.7767	-.7366	-.4921	-.6166	-.6849
-.4773	-.5963	-.6693	-.7455	-.5509	-.5442				

EDGE - X AXIS

-1.9855	-1.2857	-2.3987	-1.8763	1.6156	-1.9776	4.7812	3.8284	.2587	2.0855
.5140	.7637	-2.0983	.5143	.5788	.2284	5.3432	1.4698	4.7663	5.5373
6.1140	4.8456	6.3585	10.0011	6.2932	7.0449	8.1052	5.8795	7.1495	6.0143
7.0340	6.4783	6.9246	8.4235	5.8326	8.0244	7.8501	8.2058	7.4741	7.0481
9.4288	6.7466	6.7901	8.4666	7.4464	7.9929	7.5898	6.5490	8.3679	7.7597
7.1589	9.1048	8.9028	5.1077	10.3350	7.8990	7.7461	9.0329	8.8703	7.9157
7.7437	7.0124	8.4740	9.1629	8.4213	7.0858	9.5601	8.0853	7.1776	10.1246
7.9415	7.9724	7.7163	5.6424	9.5838	9.1166	8.1775	10.6319	6.2030	9.4546
7.7651	8.1384	9.5429	8.1853	7.9403	10.2083	6.2857	9.3123	7.5862	9.4237
7.8421	10.8912	6.0356	5.8794	7.6900	7.9369				

EDGE - Y AXIS

-1.4140	-.7168	-.5885	-1.6889	-.4636	-1.2865	-.4401	-.5996	-2.3863	-.0374
3.3569	1.5910	.7720	2.5369	1.9832	-.9792	.2495	1.3588	2.0956	2.4687
.4240	2.7047	-.0730	1.1982	2.1047	.1669	1.4386	1.5429	1.9984	.7270
2.2902	2.9423	1.8458	1.2794	2.4198	3.4231	1.5346	.9318	1.5941	2.4655
1.4775	2.9727	2.9493	3.0778	1.7408	2.4683	2.6095	2.4284	.4381	2.7460
1.6541	.3289	-.1876	4.3493	3.3726	2.3254	3.4160	2.2828	2.0668	.3781
1.8747	.2526	2.0024	2.5377	2.0275	3.0207	1.7245	1.6111	2.3392	1.9375
3.6143	2.0234	2.7110	2.9808	.4291	2.0396	1.9438	1.5190	.5291	2.2840
2.0601	3.2201	2.1601	2.9942	3.0548	.4028	3.7500	1.2019	2.8133	2.7763
1.6414	.0898	3.5762	3.8658	4.0167	2.3070				

FILTERED TRACKER DATA

CENTROID - X AXIS

0.0000	.0000	-.4488	-.2381	.1312	.1994	[illegible]	.6838	.7993	.7031
1.1060	1.4873	1.7617	1.4613	.8865	.5714	1.0075	1.7530	2.3104	2.0590
1.9450	2.2268	2.3385	2.8685	3.0698	3.0908	2.6173	2.3096	2.2763	2.3860
2.5294	2.6202	2.8443	2.5052	2.2750	2.4902	2.9501	3.3575	3.3517	3.2237
3.4550	3.5884	3.6224	3.5079	3.3988	3.2127	3.1948	3.1386	3.3102	3.2637
3.1401	3.2551	3.5530	3.4277	3.3899	3.4398	3.5057	3.5144	3.3857	3.2466
2.8439	2.5299	2.6889	3.1787	3.4114	3.3006	3.2180	3.1431	3.1901	3.2016
3.1066	3.1465	3.1073	2.7639	3.3242	3.7947	3.7364	3.4778	3.2561	3.1353
3.1127	3.2702	3.3932	3.3724	3.2172	3.6747	3.6958	3.6548	3.4391	3.2618
3.1986	3.6890	3.4479	2.5597	1.9924	2.1914				

CENTROID - Y AXIS

0.0000	0.0000	-.6598	-.3340	.1098	.5115	.6437	-.0805	.2316	.5345
.2271	-.7478	-.6931	-.0370	.6410	1.0603	.7438	.0740	-.0961	.2656
.3699	.3515	.4649	.4745	.4048	.0986	.2437	.2526	-.0948	-.4241
-.1833	.1740	.2667	.0940	-.0016	.0954	.0725	-.1371	-.2932	-.1296
.1329	.4046	.4021	.2386	-.1862	-.2157	.4136	-.6012	-.7121	-.2601
.1085	-.0014	-.3887	-.0514	.5244	.6266	.2616	.1468	.2887	.1615
.1990	.4498	.6380	.7007	.5888	.3417	.2196	.0676	.0565	.2715
.4557	.2834	.3553	.7540	.5061	.3517	.2268	.3518	.1054	.1063
.0676	.1183	.3668	.4647	.5672	.4655	.4976	.3636	.0151	.1501
.3475	.1671	.2497	.8420	1.1570	.6526				

DIG CORR - X AXIS

0.0000	0.0000	-.3232	-.2973	-.1111	.1172	.4512	.7276	.9820	1.1635
1.3177	1.0611	.9688	.9858	1.1238	1.3073	1.4052	1.4673	1.3671	1.3652
1.3842	1.6319	1.8504	1.9302	1.7743	1.7911	1.6353	1.3363	1.1019	1.1634
1.2210	1.1751	1.0585	1.0584	1.0915	1.1566	1.4733	1.8391	1.8482	1.8646
1.8496	1.7809	1.9237	2.0525	2.1168	1.9483	1.5574	1.3842	1.4003	1.4783
1.5874	1.6716	1.7521	1.6359	1.5454	1.6396	1.7470	1.8843	1.8059	1.8486
1.9696	2.1167	2.1117	1.9192	1.7077	1.6773	1.8537	2.0525	2.1745	2.0766
1.9079	1.9137	1.9142	1.8634	1.8824	1.8184	1.5742	1.5338	1.6120	2.0344
1.9773	1.7051	1.5576	1.7213	1.8891	2.0016	2.0687	2.1015	2.0880	1.9633
1.9001	2.0856	2.2191	2.0607	1.7157	1.4305				

DIG CORR - Y AXIS

0.0000	0.0000	.0818	.2454	.2387	.1365	.0255	-.0601	.0583	.1105
-1.2028	-1.1065	-.0806	-.2838	-.6130	-.2825	.5237	.5086	.2114	-.0481
.2315	.4009	.6746	.6879	.5269	.4781	.6167	.5354	.3720	.4001
.6438	.6118	.5012	.4807	.3646	-.0614	-.2808	.0124	.3862	.4370
.2406	-.0178	-.4085	-.5509	-.4248	-.1026	.1059	.0437	-.0510	-.0751
-.0881	.0558	.3508	.3617	.1355	-.0973	-.1527	.0667	.3232	.3306
.1791	-.0458	.0635	.2098	.2856	.1036	.0886	.1548	-.0256	-.2175
-.3733	-.4331	-.3588	-.2650	-.1616	-.1652	-.3028	-.4536	-.5351	-.5603
-.6390	-.7248	-.7577	-.7257	-.6537	-.6654	-.7196	-.6640	-.5873	-.5535
-.5813	-.5676	-.5571	-.6850	-.6787	-.5973				

EDGE - X AXIS

0.0000	0.0000	-1.5478	-2.3770	-.9690	-.2546	1.6815	3.5311	3.1708	1.8750
.7431	.4886	-.4581	-.7315	-.1423	.5053	2.5056	3.2828	3.6814	4.6246
5.7338	5.8502	5.7894	7.3815	8.1060	7.6891	7.3156	6.8324	6.6974	6.4035
6.5415	6.6319	6.7885	7.4620	7.2687	7.2401	7.4887	8.0314	8.0255	7.5137
7.9322	7.9281	7.3640	7.3142	7.5622	7.9154	7.8538	7.2762	7.3320	7.7043
7.7341	8.1030	8.6902	7.6388	7.7888	8.2215	8.4096	8.4021	8.6888	8.5794
8.0702	7.3782	7.5093	8.3582	8.9020	8.2551	8.2263	8.3707	8.0545	8.4665
8.7130	8.4855	7.8842	6.7865	7.2881	8.5881	9.1676	9.6244	8.5525	8.1510
7.9662	8.1284	8.6705	8.8477	8.4657	8.8051	8.2023	8.1740	7.9841	8.5487
8.5845	9.3845	8.5885	6.8700	6.1925	7.0263				

EDGE - Y AXIS

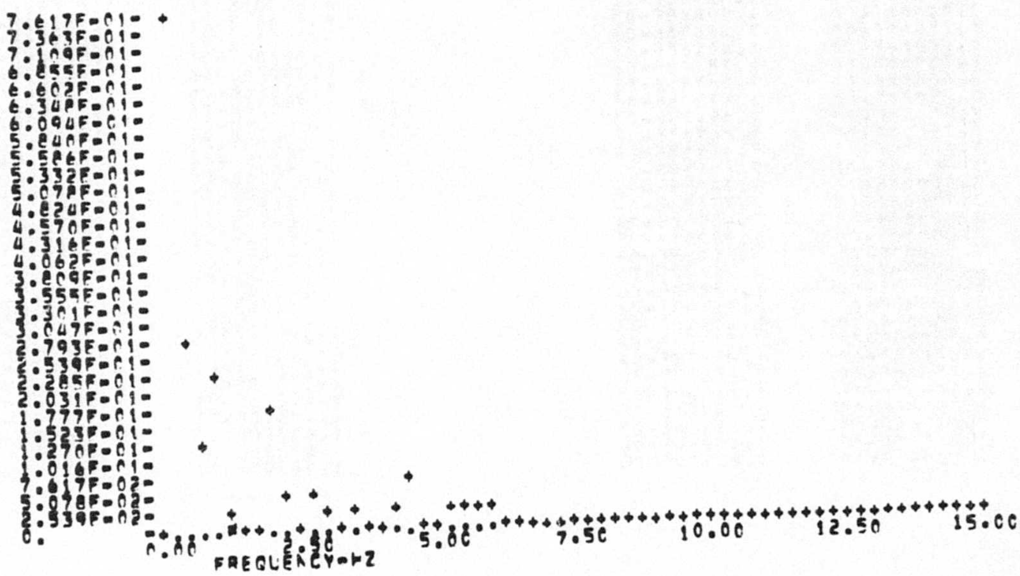
0.0000	0.0000	-.6428	-1.2547	-1.1860	-1.0636	-.7700	-.5915	-1.2024	-1.6615
.7027	2.3618	2.2109	1.7821	1.7820	.8540	-.0425	.1277	1.3179	2.2537
1.9802	1.7328	[illegible]	.7895	1.1588	1.2072	1.1244	1.2091	1.6714	1.5427
1.6127	2.2145	2.5685	2.0017	1.7665	2.4481	2.6125	1.8268	1.1673	1.5333
1.9178	2.4020	2.8071	2.7302	2.1655	1.9546	2.2536	2.5574	1.8180	1.6084
1.7183	1.3546	.3842	1.3598	3.1116	1.6848	3.3080	2.6865	2.2282	1.3559
1.0823	.8020	1.1694	1.0277	2.4113	2.7133	2.4264	1.8884	1.7796	1.9597
2.6926	2.8502	2.7185	2.6710	1.8938	1.4164	1.0965	1.7428	1.3347	1.3231
1.7532	2.6187	2.8295	2.8241	2.6788	2.0294	2.0803	2.0662	2.3069	2.5762
2.4016	1.2831	1.4806	2.8751	4.1722	3.8043				

SPECTRAL DENSITY CENTROID - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	7.61716E-01
5.00000E-01	2.70812E-01
7.50000E-01	1.18011E-01
1.00000E+00	2.18205E-01
1.25000E+00	1.69488E-02
1.50000E+00	9.56952E-03
1.75000E+00	1.40560E-03
2.00000E+00	1.84983E-01
2.25000E+00	5.12319E-02
2.50000E+00	6.80823E-03
2.75000E+00	5.55095E-02
3.00000E+00	2.43620E-02
3.25000E+00	5.28245E-04
3.50000E+00	1.81188E-02
3.75000E+00	8.96318E-03
4.00000E+00	9.00165E-04
4.25000E+00	1.83824E-02
4.50000E+00	8.47055E-02
4.75000E+00	1.24593E-02
5.00000E+00	1.16973E-02
5.25000E+00	3.58056E-02
5.50000E+00	2.19190E-02
5.75000E+00	1.92971E-02
6.00000E+00	1.41685E-02
6.25000E+00	2.55687E-03
6.50000E+00	1.26795E-02
6.75000E+00	6.39426E-03
7.00000E+00	3.15703E-03
7.25000E+00	2.96453E-03
7.50000E+00	5.19220E-03
7.75000E+00	2.38760E-03
8.00000E+00	4.44359E-03
8.25000E+00	2.36159E-03
8.50000E+00	1.95352E-03
8.75000E+00	1.71934E-03
9.00000E+00	1.06379E-03
9.25000E+00	1.17839E-03
9.50000E+00	1.66588E-03
9.75000E+00	6.80710E-04
1.00000E+01	1.86732E-04
1.02500E+01	5.87833E-04
1.05000E+01	2.67060E-04
1.07500E+01	4.64521E-03
1.10000E+01	1.52135E-03
1.12500E+01	9.18249E-05
1.15000E+01	1.51070E-03
1.17500E+01	3.95844E-04
1.20000E+01	1.48758E-03
1.22500E+01	1.99452E-03
1.25000E+01	1.12760E-04
1.27500E+01	5.21794E-04
1.30000E+01	9.76234E-04
1.32500E+01	2.28301E-03
1.35000E+01	1.69796E-03
1.37500E+01	3.51231E-05
1.40000E+01	3.13133E-03
1.42500E+01	1.36749E-03
1.45000E+01	4.12635E-04
1.47500E+01	6.20357E-04
1.50000E+01	5.19741E-05

SPECTRAL DENSITY CENTROID - X AXIS

AMPLITUDE = WATTS**2/HZ

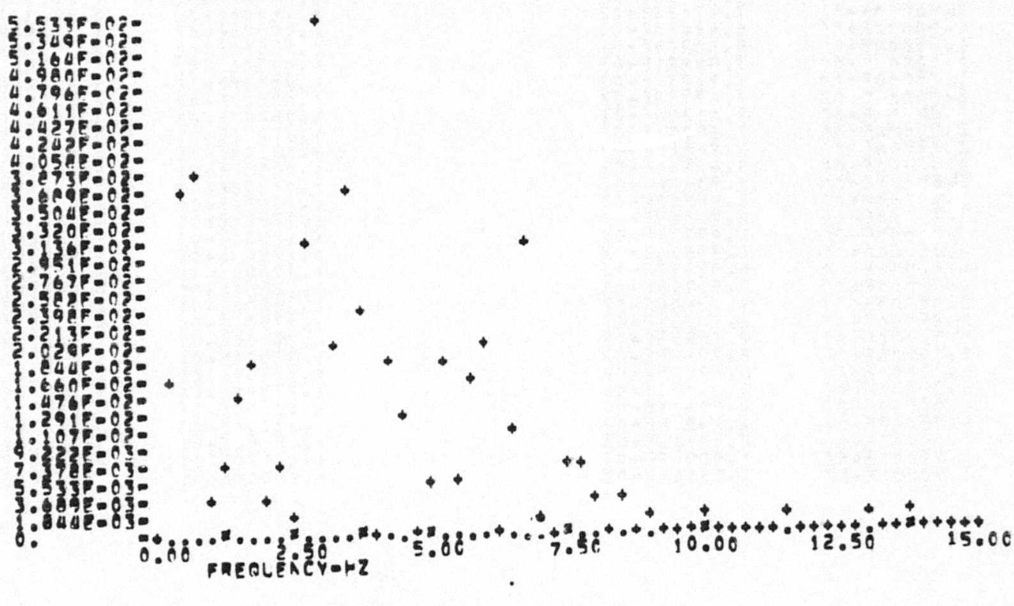


SPECTRAL DENSITY CENTROID - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.65563E-02	7.75000E+00	6.57838E-03
5.00000E-01	3.60810E-02	8.00000E+00	4.26723E-03
7.50000E-01	3.86951E-02	8.25000E+00	7.09588E-04
1.00000E+00	4.38448E-03	8.50000E+00	3.29648E-03
1.25000E+00	7.46478E-03	8.75000E+00	4.43791E-04
1.50000E+00	1.48168E-02	9.00000E+00	2.31469E-03
1.75000E+00	1.78106E-02	9.25000E+00	7.84342E-04
2.00000E+00	3.26791E-03	9.50000E+00	4.54350E-04
2.25000E+00	6.53345E-03	9.75000E+00	2.31503E-04
2.50000E+00	1.09489E-03	1.00000E+01	1.29629E-03
2.75000E+00	3.04703E-02	1.02500E+01	1.79131E-04
3.00000E+00	5.53337E-02	1.05000E+01	4.43902E-04
3.25000E+00	2.05634E-02	1.07500E+01	3.47045E-04
3.50000E+00	3.72759E-02	1.10000E+01	1.16021E-04
3.75000E+00	2.37181E-02	1.12500E+01	2.27367E-04
4.00000E+00	2.63550E-04	1.15000E+01	1.11443E-03
4.25000E+00	1.93297E-02	1.17500E+01	3.13423E-04
4.50000E+00	1.35465E-02	1.20000E+01	9.24667E-05
4.75000E+00	4.26672E-05	1.22500E+01	5.64385E-04
5.00000E+00	6.18050E-03	1.25000E+01	5.17109E-04
5.25000E+00	1.83647E-02	1.27500E+01	6.70647E-05
5.50000E+00	5.41948E-03	1.30000E+01	1.11105E-03
5.75000E+00	1.72720E-02	1.32500E+01	2.22699E-04
6.00000E+00	1.99872E-02	1.35000E+01	4.78780E-04
6.25000E+00	3.10489E-04	1.37500E+01	1.05768E-03
6.50000E+00	1.16460E-02	1.40000E+01	6.65092E-05
6.75000E+00	3.09493E-02	1.42500E+01	6.09827E-04
7.00000E+00	2.41530E-03	1.45000E+01	5.14946E-04
7.25000E+00	1.44294E-05	1.47500E+01	4.65234E-04
7.50000E+00	7.54714E-03	1.50000E+01	8.46474E-06

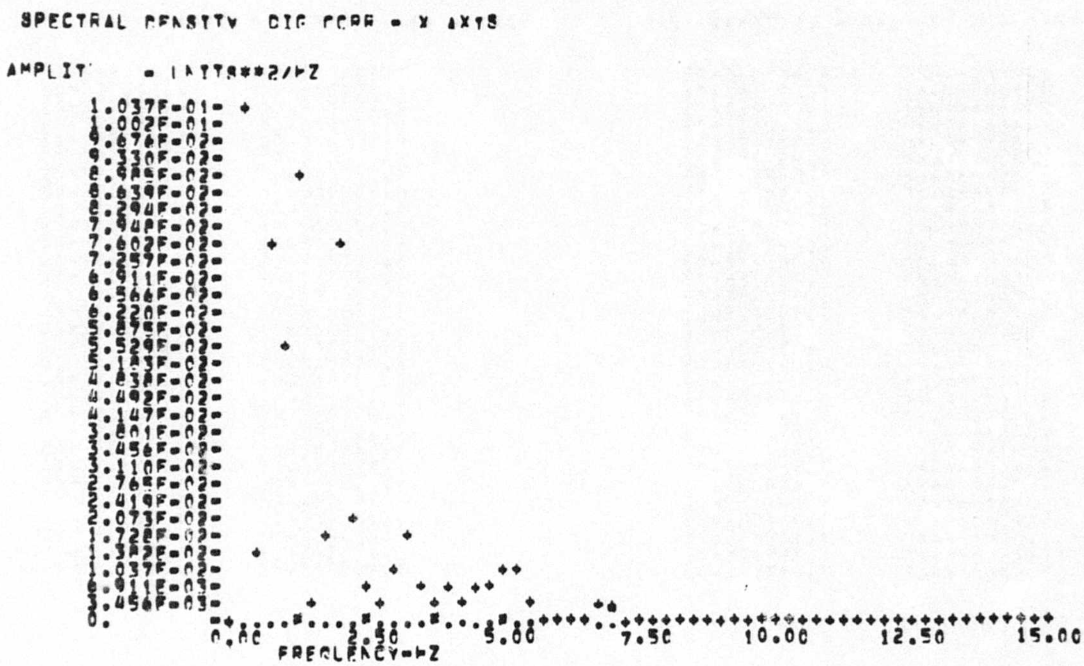
SPECTRAL DENSITY CENTROID - Y AXIS

AMPLIT[illegible] = UNITS**2/HZ



SPECTRAL DENSITY DIG CORR - X AXIS

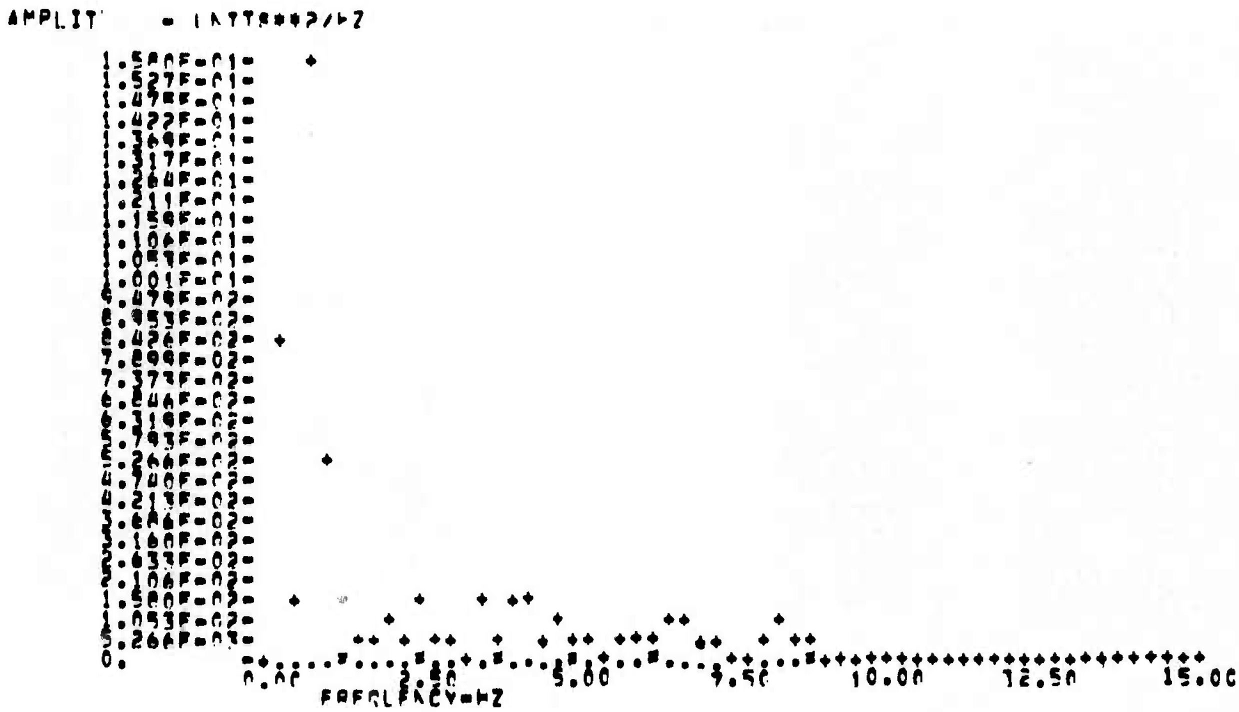
FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.03669E-01	7.75000E+00	1.62470E-03
5.00000E-01	1.52010E-02	8.00000E+00	1.28554E-03
7.50000E-01	7.77133E-02	8.25000E+00	3.37433E-04
1.00000E+00	5.67420E-02	8.50000E+00	1.27494E-03
1.25000E+00	4.00206E-02	8.75000E+00	2.15305E-04
1.50000E+00	3.85621E-03	9.00000E+00	3.11746E-04
1.75000E+00	1.71231E-02	9.25000E+00	5.36766E-05
2.00000E+00	7.67754E-02	9.50000E+00	6.27794E-04
2.25000E+00	2.01206E-02	9.75000E+00	3.42761E-04
2.50000E+00	7.35208E-03	1.00000E+01	2.57672E-04
2.75000E+00	2.96819E-03	1.02500E+01	4.09346E-04
3.00000E+00	9.64996E-03	1.05000E+01	4.06797E-04
3.25000E+00	1.83616E-02	1.07500E+01	7.49446E-04
3.50000E+00	5.68582E-03	1.10000E+01	6.91303E-04
3.75000E+00	2.24019E-03	1.12500E+01	[illegible].85534E-06
4.00000E+00	7.87708E-03	1.15000E+01	1.07029E-04
4.25000E+00	4.89976E-03	1.17500E+01	1.79918E-04
4.50000E+00	6.05577E-03	1.20000E+01	3.17264E-04
4.75000E+00	7.96773E-03	1.22500E+01	5.99987E-04
5.00000E+00	1.13602E-02	1.25000E+01	2.52721E-05
5.25000E+00	8.84831E-03	1.27500E+01	5.74173E-05
5.50000E+00	2.18958E-03	1.30000E+01	7.08222E-04
5.75000E+00	8.27629E-04	1.32500E+01	8.70470E-04
6.00000E+00	9.07025E-04	1.35000E+01	4.30550E-04
6.25000E+00	4.04133E-04	1.37500E+01	7.29846E-05
6.50000E+00	4.90631E-04	1.40000E+01	5.05840E-04
6.75000E+00	4.24279E-03	1.42500E+01	4.94276E-04
7.00000E+00	2.38134E-03	1.45000E+01	3.73224E-04
7.25000E+00	1.50997E-03	1.47500E+01	2.99005E-04
7.50000E+00	7.73169E-05	1.50000E+01	3.05584E-05


1.037E-01
1.002E-01
0.00
2.50
5.00
7.50
10.00
12.50
15.00

SPECTRAL DENSITY DIG CORR - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	8.40833E-02	7.75000E+00	1.24092E-03
5.00000E-01	1.69118E-02	8.00000E+00	4.07390E-03
7.50000E-01	1.57986E-01	8.25000E+00	8.72927E-03
1.00000E+00	5.14243E-02	8.50000E+00	3.88669E-03
1.25000E+00	1.78144E-02	8.75000E+00	3.30490E-03
1.50000E+00	3.72775E-03	9.00000E+00	2.04039E-03
1.75000E+00	5.59732E-03	9.25000E+00	1.38629E-03
2.00000E+00	9.09098E-03	9.50000E+00	1.06652E-03
2.25000E+00	2.65615E-03	9.75000E+00	8.01053E-04
2.50000E+00	1.79809E-02	1.00000E+01	8.61058E-04
2.75000E+00	4.82343E-03	1.02500E+01	7.62439E-04
3.00000E+00	5.99128E-03	1.05000E+01	8.08766E-04
3.25000E+00	1.94818E-03	1.07500E+01	4.14938E-04
3.50000E+00	1.77495E-02	1.10000E+01	5.17245E-04
3.75000E+00	6.74483E-03	1.12500E+01	6.15037E-04
4.00000E+00	1.47950E-02	1.15000E+01	5.78826E-04
4.25000E+00	1.33847E-02	1.17500E+01	3.55957E-04
4.50000E+00	6.25320E-03	1.20000E+01	3.36690E-04
4.75000E+00	8.03578E-03	1.22500E+01	1.80741E-04
5.00000E+00	5.26730E-03	1.25000E+01	2.32124E-04
5.25000E+00	3.16405E-03	1.27500E+01	1.64671E-04
5.50000E+00	1.03212E-03	1.30000E+01	2.72989E-04
5.75000E+00	4.64849E-03	1.32500E+01	7.68723E-05
6.00000E+00	7.60976E-03	1.35000E+01	1.55618E-04
6.25000E+00	3.19928E-03	1.37500E+01	1.60001E-04
6.50000E+00	1.14115E-02	1.40000E+01	2.15292E-04
6.75000E+00	9.28255E-03	1.42500E+01	4.91196E-04
7.00000E+00	7.10436E-03	1.45000E+01	1.99155E-04
7.25000E+00	7.75562E-03	1.47500E+01	6.71775E-05
7.50000E+00	2.48715E-03	1.50000E+01	4.32288E-05

SPECTRAL DENSITY RIG CORR = Y AXIS



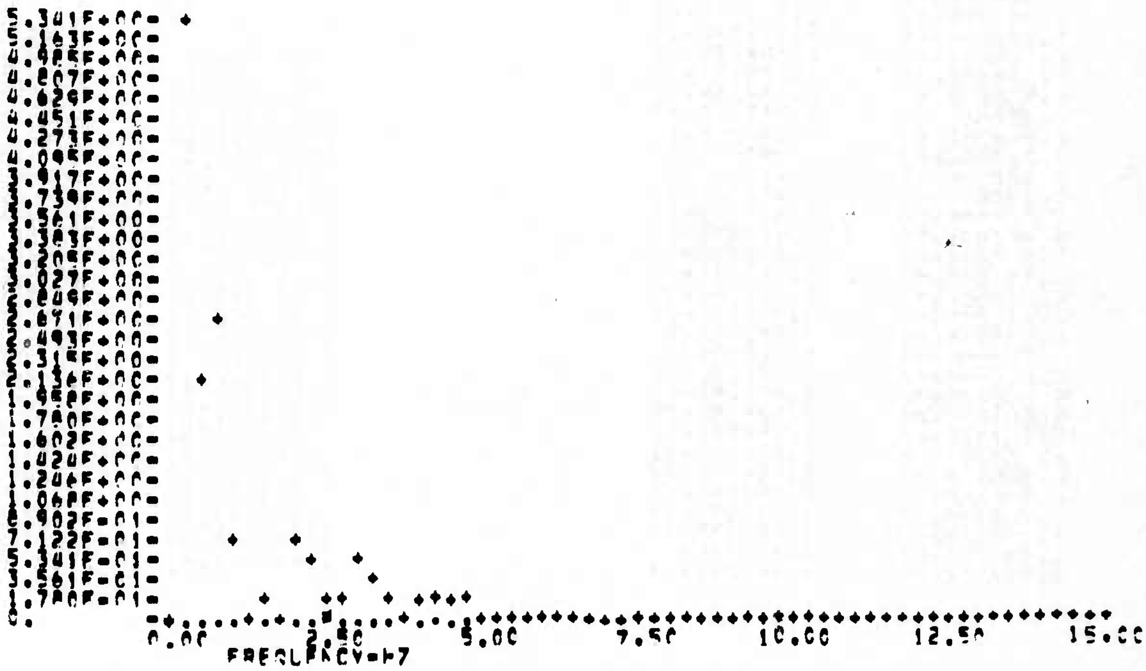
SPECTRAL DENSITY FREE - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	5.34117E+00
5.00000E-01	2.15230E+00
7.50000E-01	2.58934E+00
1.00000E+00	6.79450E-01
1.25000E+00	4.13673E-02
1.50000E+00	2.48758E-01
1.75000E+00	7.72999E-02
2.00000E+00	7.76839E-01
2.25000E+00	5.89957E-01
2.50000E+00	2.48435E-01
2.75000E+00	1.09066E-01
3.00000E+00	5.72657E-01
3.25000E+00	2.75730E-01
3.50000E+00	1.68702E-01
3.75000E+00	4.95735E-02
4.00000E+00	1.76560E-01
4.25000E+00	1.27339E-01
4.50000E+00	1.83563E-01
4.75000E+00	1.40325E-01
5.00000E+00	1.28001E-02
5.25000E+00	5.01597E-02
5.50000E+00	1.88660E-02
5.75000E+00	5.87059E-02
6.00000E+00	4.39150E-02
6.25000E+00	8.49955E-03
6.50000E+00	9.16685E-03
6.75000E+00	3.30369E-02
7.00000E+00	4.89348E-02
7.25000E+00	2.55555E-03
7.50000E+00	3.62298E-02

FREQ - HZ	AMP - UNITS**2/HZ
7.75000E+00	1.38415E-03
8.00000E+00	5.76728E-03
8.25000E+00	3.14903E-02
8.50000E+00	2.68125E-04
8.75000E+00	9.61266E-03
9.00000E+00	8.05988E-04
9.25000E+00	1.19109E-02
9.50000E+00	2.24577E-02
9.75000E+00	4.38133E-03
1.00000E+01	8.02167E-03
1.02500E+01	7.51008E-03
1.05000E+01	9.10735E-04
1.07500E+01	2.12339E-02
1.10000E+01	7.32151E-03
1.12500E+01	1.69573E-04
1.15000E+01	1.00033E-02
1.17500E+01	2.38552E-03
1.20000E+01	1.20630E-02
1.22500E+01	1.52483E-02
1.25000E+01	4.76542E-03
1.27500E+01	1.04072E-02
1.30000E+01	6.45444E-03
1.32500E+01	2.62256E-03
1.35000E+01	2.33151E-03
1.37500E+01	7.32506E-04
1.40000E+01	3.11011E-03
1.42500E+01	1.13189E-02
1.45000E+01	1.68423E-03
1.47500E+01	1.04657E-03
1.50000E+01	1.51742E-04

SPECTRAL DENSITY FORCE - X AXIS

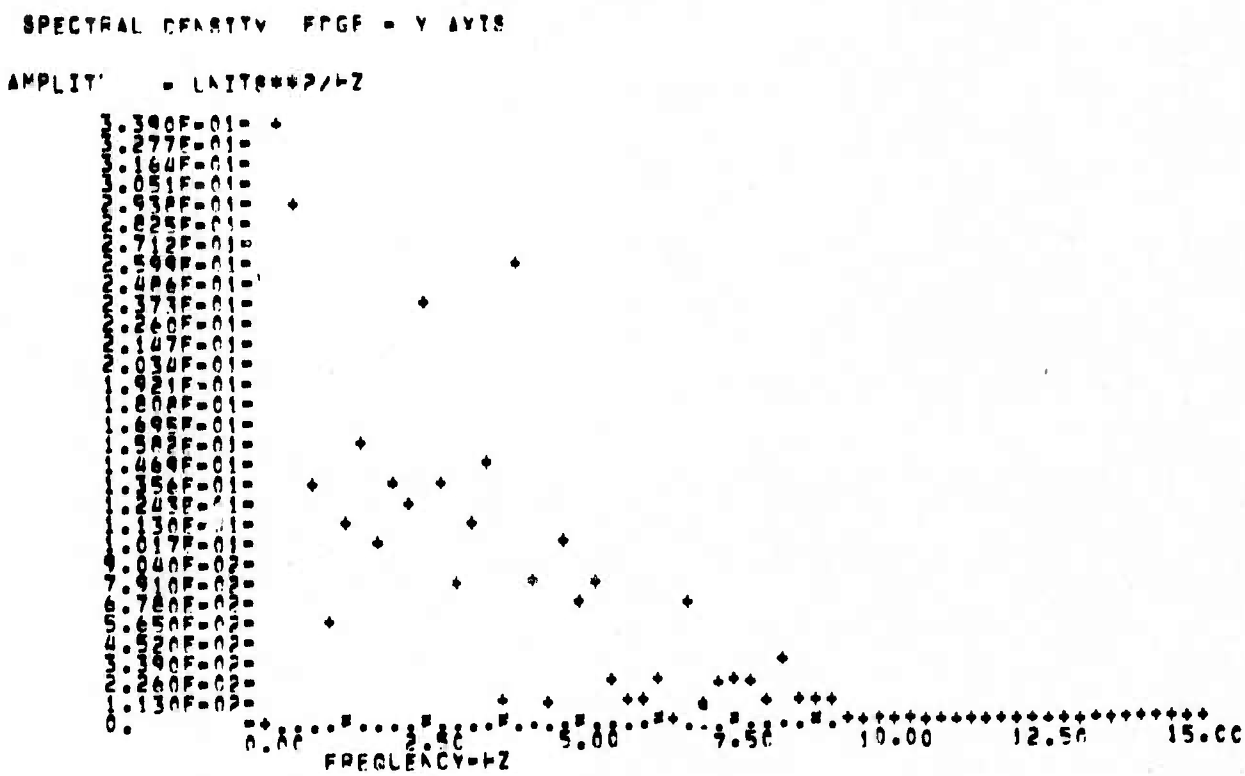
AMPLITUDE = UNITS**2/HZ



SPECTRAL DENSITY EDGE - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.500000E-01	3.38953E-01
5.000000E-01	2.94488E-01
7.500000E-01	1.31675E-01
1.000000E+00	6.09858E-02
1.250000E+00	1.12315E-01
1.500000E+00	1.53315E-01
1.750000E+00	6.90741E-02
2.000000E+00	1.40035E-01
2.250000E+00	1.39545E-01
2.500000E+00	2.41512E-01
2.750000E+00	1.40576E-01
3.000000E+00	7.92232E-02
3.250000E+00	1.14758E-01
3.500000E+00	1.42549E-01
3.750000E+00	1.12757E-02
4.000000E+00	2.61132E-01
4.250000E+00	7.81146E-02
4.500000E+00	5.90180E-03
4.750000E+00	1.01787E-01
5.000000E+00	7.08015E-02
5.250000E+00	7.89665E-02
5.500000E+00	2.02909E-02
5.750000E+00	1.45858E-02
6.000000E+00	1.58263E-02
6.250000E+00	2.09650E-02
6.500000E+00	5.12209E-03
6.750000E+00	6.43055E-02
7.000000E+00	1.00083E-02
7.250000E+00	2.71349E-02
7.500000E+00	1.99324E-02

FREQ - HZ	AMP - UNITS**2/HZ
7.75000E+00	1.83327E-02
8.00000E+00	5.91588E-03
8.25000E+00	3.71379E-02
8.50000E+00	7.78671E-03
8.75000E+00	1.10408E-02
9.00000E+00	1.01298E-02
9.25000E+00	3.57384E-03
9.50000E+00	8.53523E-04
9.75000E+00	2.54308E-03
1.00000E+01	9.00478E-05
1.02500E+01	1.87575E-03
1.05000E+01	1.74148E-03
1.07500E+01	1.10159E-04
1.10000E+01	1.72045E-03
1.12500E+01	1.26960E-03
1.15000E+01	1.72423E-03
1.17500E+01	3.30336E-04
1.20000E+01	7.74173E-04
1.22500E+01	1.64212E-03
1.25000E+01	3.77191E-05
1.27500E+01	7.11050E-04
1.30000E+01	2.66608E-03
1.32500E+01	1.84038E-04
1.35000E+01	1.41514E-03
1.37500E+01	1.70174E-03
1.40000E+01	1.85197E-03
1.42500E+01	4.03472E-04
1.45000E+01	3.62256E-04
1.47500E+01	5.18789E-04
1.50000E+01	3.11088E-05


SPECTRAL DENSITY EDGE - Y AXIS
AMPLIT' = UNITS**2/HZ
FREQUENCY-HZ

CDC 6600 CSP Printout IV

Reference Program: Processing of TV data run no. 5

Tracking Program: Run no. 86 using above referenced data

```
DIGITAL CORRELATION TRACKER  -  REFERENCING PROGRAM

PROCESS101 PICTURES
SEARCH WINDOW IS 16 X  16
STARTING TARGET COORDINATES ARE (44,42)
TAPE OUTPUT OPTION IS 1

CONTRAST ......NEG
```

COORDINATE ERROR ANALYSIS

STARTING COORDINATES * X= 42.00
Y= 44.00

****

NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR
1	1.11	[illegible]	2	.69	-3.51	3	1.94	-3.10
4	2.05	-2.5[illegible]	5	.63	-1.75	6	-.25	-1.50
7	-1.15	-2.81	8	-1.69	-.63	9	-3.31	-4.75
10	-.75	-6.[illegible]	11	-.50	-1.81	12	-3.63	-5.44
13	-4.69	-4.34	14	-2.94	-3.33	15	-5.25	-3.88
16	-5.75	-2.63	17	-4.13	-6.31	18	-5.94	-3.56
19	-4.81	-4.31	20	-7.34	-2.94	21	-1.13	-7.31
22	-3.31	-4.63	23	-4.19	-4.75	24	-1.69	-3.50
25	-8.03	-8.33	26	-2.91	-6.16	27	-3.81	-7.94
28	-3.25	-6.19	29	-1.56	-5.00	30	-3.69	-9.06
31	-5.01	-4.44	32	-4.91	-3.33	33	-6.19	-6.25
34	-5.44	-9.81	35	-5.75	-5.38	36	-5.31	-5.94
37	-5.51	-7.33	38	-5.31	-3.56	39	-5.63	-8.94
40	-4.05	-7.91	41	-3.56	-7.25	42	-2.94	-4.94
43	-6.51	-3.[illegible]	44	-2.75	-4.81	45	-.31	-5.94
46	-1.53	-8.13	47	.88	-5.38	48	-1.0	-6.06
49	-5.25	-8.38	50	-6.94	-6.75	51	-6.13	-5.31
52	-5.38	-4.63	53	-5.88	-6.25	54	-6.06	-6.50
55	-3.51	-2.63	56	-3.94	-4.33	57	-3.5[illegible]	-3.69
58	-3.69	-6.5[illegible]	59	-4.25	-2.06	60	-3.38	-4.44
61	-2.81	-4.34	62	-1.25	-4.63	63	-2.13	-2.25
64	-4.31	-5.44	65	-3.44	-5.88	66	-1.38	-6.31
67	-.13	-6.[illegible]	68	-1.94	-2.94	69	.56	-4.31
70	-2.05	-1.[illegible]5	71	.50	-3.13	72	-3.31	-3.56
73	-1.83	-3.44	74	-.06	-5.00	75	-.56	-3.63
76	-1.13	-1.00	77	.44	-.13	78	.81	-4.00
79	-1.05	-4.13	80	-3.44	-3.06	81	-3.13	-1.31
82	-2.31	-2.50	83	-1.75	-3.44	84	-1.55	-.06
85	.75	-5.25	86	1.31	-3.06	87	.5[illegible]	-.63
88	-2.13	-3.31	89	-5.50	-2.88	90	-2.0[illegible]	-3.50
91	-3.81	-2.89	92	-.69	.25	93	-2.50	.50
94	-2.69	-1.34	95	-2.38	.25	96	-3.63	-2.88
97	-1.63	-1.69	98	-4.13	-1.31	99	-2.06	-1.94
100	-2.56	-3.5[illegible]						

SIGNAL/NOISE DETERMINATION

SAMPLE	SIGNAL LEVEL	NOISE LEVEL	S/N
1	7.10	1.64	4.33
2	15.80	7.54	2.10
3	18.11	4.41	4.11
4	12.63	4.29	3.[illegible]9
5	8.04	3.64	2.21
6	4.90	3.40	1.44
7	8.50	3.39	2.51
8	11.29	3.58	3.15
9	11.35	3.34	3.40
10	13.37	3.32	4.03

RESULTANT SIGNAL/NOISE = 3.835

TRACKING RUN NO. 36

```
X DIMENSION = 16      Y DIMENSION = 16
X CENTER = 32         Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
  0 FRAMES SKIPPED,  99 FRAMES PROCESSED
FREQUENCY =  30.00
5 INPUT BITS USED
ICOLPS = 0      ICFF = 0
SCALOF =   4.00     SPACX =   5.00     SPACY =   5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT  4 FRAMES(SKIP)
LINEAR PROCESSING ABOVE THRESHOLD OF - 20 FOR CENTROID TRACKER

CENTROID - X AXIS  GAIN =     .55203

CENTROID - Y AXIS  GAIN =     .52075

DIG CORR - X AXIS  GAIN =    1.00000

DIG CORR - Y AXIS  GAIN =    1.00000

EDGE - X AXIS      GAIN =     .39479

EDGE - Y AXIS      GAIN =     .32562
```

SAMPLE NO. 98 RUN NO. 86

INPUT PICTURE (X OFFSET = -2, Y OFFSET = -4)

INPUT DATA DIVIDED BY 2

3	3	3	3	3	3	3	3	2	3	3	3	4	6	6	7	6	5	4	3	3	2	2	3	2	3	3	3	2	2	3	2
3	3	3	3	3	3	3	3	2	3	3	4	4	6	7	7	6	5	4	3	3	2	3	3	2	3	2	2	3	2	2	2
3	3	3	3	3	3	3	3	3	3	3	4	6	6	8	7	6	5	4	3	3	3	3	3	3	3	3	2	3	2	2	3
3	3	3	2	3	3	3	3	3	3	3	4	6	7	8	8	7	6	5	4	4	3	3	3	2	3	3	3	2	2	2	2
3	3	3	2	3	3	3	3	3	3	4	4	6	8	8	9	9	8	7	6	5	4	3	3	2	3	2	2	3	2	2	2
3	3	3	3	3	3	3	3	3	3	4	5	7	8	9	1	1	1	9	7	6	4	3	3	3	2	2	3	3	2	2	3
3	3	3	3	3	3	3	4	3	4	4	6	8	9	1	1	2	2	1	8	6	4	3	3	3	3	3	3	3	2	2	3
4	4	4	4	4	4	4	4	5	6	7	8	1	1	1	2	3	K	1	9	6	4	4	3	3	3	3	3	3	2	3	3
5	6	6	6	7	6	7	8	8	9	1	1	1	1	2	3	K	K	3	1	8	5	4	4	3	3	3	2	3	3	3	3
8	9	1	1	1	1	1	2	2	3	3	3	2	2	K	K	K	K	2	1	8	6	4	4	3	3	3	3	3	2	3	3
3	K	5	5	5	K	5	5	9	5	5	K	K	K	K	K	K	3	1	9	7	5	4	3	3	3	3	2	2	2	2	3
K	9	9	9	9	9	9	9	9	K	K	3	3	3	3	K	3	2	1	6	5	4	4	3	3	3	3	3	3	3	2	2
1	1	1	1	1	1	1	9	8	9	1	1	1	1	2	3	2	1	8	6	4	3	3	3	3	3	3	3	3	2	2	2
6	6	6	6	6	6	6	6	6	6	7	8	1	1	1	1	1	8	6	4	3	3	3	3	3	3	3	3	3	2	3	3
4	4	4	4	4	4	4	4	4	5	6	8	9	9	8	8	6	6	4	4	4	3	3	3	2	3	3	2	2	2	2	3
3	4	4	3	3	3	3	3	3	5	6	7	8	8	8	6	4	4	3	3	3	3	3	3	3	3	2	2	3	2	2	3
4	3	3	3	3	3	3	3	4	4	6	7	8	8	6	5	4	4	3	3	3	3	2	2	3	3	3	2	3	2	2	2
4	4	3	3	3	3	3	4	3	4	6	7	8	7	6	5	4	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3
3	3	3	3	3	3	3	3	3	4	6	7	8	8	6	4	3	3	3	3	3	3	3	3	2	3	3	2	3	2	3	3
3	3	3	3	3	3	3	3	3	4	6	7	8	7	6	4	3	3	3	3	3	3	3	2	2	2	3	3	2	2	3	2
3	3	3	3	3	3	3	3	3	5	6	7	8	7	6	4	3	3	3	3	3	2	3	2	2	3	3	2	2	2	3	3
3	3	3	3	4	3	3	3	4	5	6	7	8	7	6	4	3	3	3	3	3	2	3	3	2	3	3	2	2	2	2	2
3	3	3	3	3	3	3	3	3	5	6	7	8	6	5	4	3	3	3	3	2	3	3	2	2	3	2	2	2	2	2	2
3	4	3	3	3	3	3	3	3	5	6	7	8	6	4	4	3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	3
3	3	3	2	3	3	3	4	4	4	6	7	7	6	4	4	3	3	3	3	3	2	3	3	2	2	2	2	3	2	2	3
3	3	3	3	3	3	3	4	3	5	6	7	7	6	4	4	3	3	3	2	3	3	3	3	2	3	3	2	2	2	2	3
3	3	3	3	3	3	3	3	4	5	6	6	6	6	4	4	3	3	3	3	3	3	3	3	2	3	3	2	3	2	2	2
3	3	3	3	3	3	3	3	4	5	6	6	6	6	5	4	3	3	3	3	3	3	3	3	2	3	3	2	3	2	3	3
3	3	3	3	3	3	3	4	4	6	7	6	6	6	4	4	3	3	3	3	3	3	3	2	2	3	3	2	3	2	3	3
3	3	3	3	3	3	3	4	4	6	7	6	6	5	4	3	3	3	2	3	3	2	3	3	2	3	3	2	3	3	3	3
3	3	3	3	3	3	3	4	4	6	7	7	6	4	4	3	3	3	3	2	3	2	3	3	3	3	3	2	3	3	3	3
3	3	3	3	4	3	3	4	4	6	6	6	6	4	4	3	3	3	3	3	3	2	3	3	3	3	3	2	3	2	2	3

SAMPLE NO. 98   RUN NO. 86

VIDEO GRADIENTS

INPUT DATA DIVIDED BY 2

```
. . . . . . . . . . 1 1 2 1 . 1 1 2 . . . . . 1 1 . 1 . 1 . . .
. . . . . . . . . . 1 2 2 2 1 1 1 1 . . . . . . . . 1 1 . . . .
. . . . . . . . . . . 3 1 2 1 2 2 2 1 1 1 . . . . . 1 . . . 1 .
. . . 1 . . . . . . 1 2 2 1 1 2 3 3 3 2 2 1 . . . . . . . . . .
. . . . . . . . . . 1 2 2 1 2 2 2 3 3 2 2 1 . . . . . . . . 1 .
. . . . . . 1 1 1 1 3 2 2 2 2 2 3 3 3 2 3 . . . . . . . . . . .
. . 1 1 1 1 1 1 3 3 3 3 2 2 2 1 1 4 4 3 3 1 1 . . . . . . . . .
2 3 3 3 4 4 5 5 5 5 5 4 2 2 2 1 1 3 5 4 4 1 1 1 . . . . . . . .
4 5 7 7 6 6 6 7 7 5 4 2 1 2 2 . . 2 4 3 4 2 . 1 . . . . . . . .
7 8 7 6 6 6 5 4 3 3 2 2 2 2 . . . 3 4 3 4 2 1 1 . . . . . . . .
2 1 . . 1 1 . . 1 1 2 2 1 1 1 1 1 4 5 3 2 1 1 . . . . . . . . .
7 7 6 6 8 8 9 9 9 7 5 4 3 2 1 1 2 4 5 2 2 1 1 . . . . . . . . .
5 6 7 6 6 6 5 4 4 5 4 2 2 3 4 4 4 4 4 2 1 . . . . . . . . . . .
3 3 3 3 3 3 2 2 2 2 2 2 1 1 3 5 5 4 2 . 1 . . . . . . . . . . .
1 . 1 1 . . 1 1 1 2 1 2 1 1 2 3 2 2 1 1 1 . . . . . . . . . . .
. 1 1 . . . . . 1 2 . 2 . 2 2 3 . 1 . . . . . . . . . . 1 . 1 .
. 1 . . . . 1 . 1 2 1 2 1 1 2 2 . 1 . . . . . . . . . . . . 1 .
. 1 . . . . 1 . 1 2 1 2 1 1 2 1 . . . . . . . . . . . . 1 1 . .
. . . . . . . . 1 2 1 2 1 2 2 1 . . . . . . . 1 1 . . . . 1 . .
. . . . . . . . 2 2 1 1 1 1 2 1 . . . . . . . . 1 . . . . . . .
. . . 1 1 . . . 2 2 1 1 1 1 2 2 . . . . 1 1 . . . . . . . . . .
. . . 1 1 . . . 2 2 1 1 2 2 2 2 . . . . . 1 . . . . . . . . . .
1 1 . . . . . . 2 2 . 1 2 2 1 1 . . . . . . . . . . . . 1 . . .
1 . 1 . . . . . 2 2 1 1 2 2 . 1 . . . . . . . . . . . . . . . .
. . 1 1 . . 1 . 1 2 1 . 1 2 . 1 . . . . . . . . . . . . . . . .
. . . . . . 1 . 2 2 . . 1 2 . 1 . . . . . . . . . . . . . . . .
. . . . . . . . 2 2 . . . 2 1 . . . . . . . . . . . . . . . . .
. . . . . . 1 . 2 1 . . . 2 1 1 . . . . . . . . . . . . . . . .
. . . . . . 1 . 3 1 . . 1 2 1 1 . . . . . . . . . . . . . . . .
. . . . . . 1 . 3 1 . . 2 1 . . . . . . . . . . . . . . . . . .
. . . 1 . . 1 . 3 1 . 1 2 . . . . . . . . . . . . . 1 1 . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 98 RUN NO. 86

EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

```
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . 1 1 1 . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 1 1 . . . . . . . . . . . . .
. . . . . . . . . . 1 . . . . . 1 1 1 . 1 . . . . . . . . . . .
. . . . . . . . 1 1 1 1 . . . . . 1 1 1 1 . . . . . . . . . . .
. 1 1 1 1 1 1 1 1 1 1 1 . . . . . 1 1 1 1 . . . . . . . . . . .
1 1 1 1 1 1 1 1 1 1 1 . . . . . . . 1 1 1 . . . . . . . . . . .
1 1 1 1 1 1 1 1 1 1 . . . . . . . 1 1 1 1 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 1 1 1 . . . . . . . . . . . .
1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . 1 1 . . . . . . . . . . . . .
1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 . . . . . . . . . . . . .
1 1 1 1 1 1 . . . . . . . . 1 1 1 1 . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . 1 . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . 1 . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 92 RUN NO. 86

DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

3	3	3	3	3	3	3	3	2	3	3	3	4	6	6	7	6	5	4	3	3	2	2	3	2	3	3	3	2	2	3	2
3	3	3	3	3	3	3	3	2	3	3	4	4	6	7	7	6	5	4	3	3	2	3	3	2	3	2	2	3	2	2	2
3	3	3	3	3	3	3	3	3	3	3	4	6	6	8	7	6	5	4	3	3	3	3	3	3	3	3	2	3	2	2	3
3	3	3	2	3	3	3	3	3	3	3	4	6	7	8	8	7	6	5	4	4	3	3	3	2	3	3	3	2	2	2	2
3	3	3	2	3	3	3	3	3	3	4	4	6	8	8	9	9	9	7	6	5	4	3	3	2	3	2	2	3	2	2	2
3	3	3	3	3	3	3	3	3	3	4	5	7	8	9	1	[illegible]	[illegible]	9	7	6	4	3	3	3	2	2	3	3	2	2	3
3	3	3	3	3	3	3	4	3	4	4	6	8	9	[illegible]	1	2	2	[illegible]	8	6	4	3	3	3	3	3	3	3	2	2	3
4	4	4	4	4	4	4	4	5	6	7	8	[illegible]	[illegible]	1	2	3	K	1	9	6	4	4	3	3	3	3	3	3	2	3	3
5	6	6	6	7	6	7	8	8	9	[illegible]	1	1	1	2	3	K	K	3	[illegible]	8	5	4	4	3	3	3	2	3	3	3	3
8	9	[illegible]	1	1	[illegible]	1	2	3	3	3	3	2	2	K	K	K	K	2	[illegible]	8	6	4	4	3	3	3	3	3	2	3	3
3	K	9	9	9	K	9	9	9	9	9	K	K	K	K	[illegible]	K	3	1	9	7	5	4	3	3	3	3	2	2	2	2	3
K	9	9	9	9	9	9	9	9	K	K	3	3	3	3	K	3	2	[illegible]	6	5	4	4	3	3	3	3	3	3	3	2	2
[illegible]	[illegible]	1	1	[illegible]	[illegible]	[illegible]	9	8	9	[illegible]	[illegible]	1	1	2	3	2	1	8	6	4	3	3	3	3	3	3	3	3	2	2	2
6	6	6	6	6	6	6	6	6	6	7	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	6	4	3	3	3	3	3	3	3	3	3	2	3	3
4	4	4	4	4	4	4	4	4	5	6	8	9	9	8	8	6	6	4	4	4	3	3	3	2	3	3	2	2	2	2	3
3	4	4	3	3	3	3	3	3	5	6	7	8	8	8	6	4	4	3	3	3	3	3	3	3	3	2	2	3	2	2	3
4	3	3	3	3	3	3	3	4	4	6	7	8	8	6	5	4	4	3	3	3	3	2	2	3	3	3	2	3	2	2	2
4	4	3	3	3	3	3	4	3	4	6	7	8	7	6	5	4	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3
3	3	3	3	3	3	3	3	3	4	6	7	8	8	6	4	3	3	3	3	3	3	3	3	2	3	3	2	3	2	3	3
3	3	3	3	3	3	3	3	3	4	6	7	8	7	6	4	3	3	3	3	3	3	3	2	2	2	3	3	2	2	3	2
3	3	3	3	3	3	3	3	3	5	6	7	8	7	6	4	3	3	3	3	3	2	3	2	2	3	3	2	2	2	3	3
3	3	3	3	4	3	3	3	4	5	6	7	8	7	6	4	3	3	3	3	3	2	3	3	2	3	3	2	2	2	2	2
3	3	3	3	3	3	3	3	3	5	6	7	8	6	5	4	3	3	3	3	2	3	3	2	2	3	2	2	2	2	2	2
3	4	3	3	3	3	3	3	3	5	6	7	8	6	4	4	3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	3
3	3	3	2	3	3	3	4	4	4	6	7	7	6	4	4	3	3	3	3	3	2	3	3	2	2	2	2	3	2	2	3
3	3	3	3	3	3	3	4	3	5	6	7	7	6	4	4	3	3	3	2	3	3	3	3	2	3	3	2	2	2	2	3
3	3	3	3	3	3	3	3	4	5	6	6	6	6	4	4	3	3	3	3	3	3	3	3	2	3	3	2	3	2	2	2
3	3	3	3	3	3	3	3	4	5	6	6	6	6	5	4	3	3	3	3	3	3	3	3	2	3	3	2	3	2	3	3
3	3	3	3	3	3	3	4	4	6	7	6	6	6	4	4	3	3	3	3	3	3	3	2	2	3	3	2	3	2	3	3
3	3	3	3	3	3	3	4	4	6	7	6	6	5	4	3	3	3	2	3	3	2	3	3	2	3	3	2	3	3	3	3
3	3	3	3	3	3	3	4	4	6	7	7	6	4	4	3	3	3	3	2	3	2	3	3	3	3	3	2	3	3	3	3
3	3	3	3	4	3	3	4	4	6	6	6	6	4	4	3	3	3	3	3	3	2	3	3	3	3	3	2	3	2	2	3

~~SAMPLE NO. 98~~   RUN NO. 86

CENTROID TRACKER INPUT DATA

~~INPUT DATA DIVIDED~~ BY 2

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. . . . . . . . . . . . 1 1 2 2 3 4 2 . . . . . . . . . . . . .
. . . . . . . . . . 1 2 2 2 2 3 4 4 3 1 . . . . . . . . . . . .
. . 1 2 2 1 2 2 2 2 3 3 2 2 4 4 4 4 2 1 . . . . . . . . . . . .
3 4 5 5 5 4 5 5 5 5 5 4 4 4 4 4 4 3 2 . . . . . . . . . . . . .
4 5 5 5 5 5 5 5 5 4 4 3 3 3 3 4 3 2 1 . . . . . . . . . . . . .
1 1 2 2 1 1 1 . . . 1 1 2 2 2 3 2 2 . . . . . . . . . . . . . .
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SAMPLE NO. 98   RUN NO. 86

CORRELATION REFERENCE MATRIX

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 7 8121720212323191410 7 7 7 6 6
 8111418212223232015 10 8 7 7 6 6
12151921212224242218 12 8 7 7 7 6
1821222323232424231915 10 8 7 7 6
262625262525262522171311 8 7 6 6
3029272727262624191411 9 8 7 6 6
27282827272726231712 9 8 7 7 6 6
20212324242322191511 9 7 6 6 6 6
131619212019171412 9 9 7 6 6 7 6
1115181918141211 9 8 7 7 6 6 6 6
101418191612 9 9 7 7 7 7 6 6 6 6
101417171511 9 7 7 7 7 6 6 6 6 6
101417171411 9 7 7 6 5 6 6 6 6 6
 91316171510 8 7 7 6 6 6 6 6 6 6
101316171410 8 6 6 6 6 6 6 6 6 5
 91417171410 9 6 6 6 6 6 6 5 6 6
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TRACKING ERRORS

EDGE ERRORS XM= -.8131   YM= -5.7257   XC= 1.1274   YC= -1.6632

CENTROID ERRORS XM= -.0237   YM= -5.4721   XC= 1.9138   YC= -1.4096

CORRELATION ERRORS XM= 2.2399   YM= -3.0356   XC= 4.1774   YC= 1.0269

FRAME OFFSETS -2 -4   INPUT INCR. ERRORS   .0625   -.0625

FINAL SEARCH CORRELATIONS -
8.58E+02 5.34E+02 4.78E+02 6.46E+02 3.56E+02 3.60E+02 6.74E+02 4.86E+02 6.84E+02

STATISTICAL DATA

		RESOLUTION ELEMENTS				REGRESSION COEF
CENTROID - X AXIS	MEAN	1.804514E+00	RMS	2.465038E+00	BETA	-1.915811E-02
CENTROID - Y AXIS	MEAN	-9.571041E-01	RMS	2.214828E+00	BETA	-7.005036E-02
RADIAL ERROR(RMS)=		3.3139	DRIFT DISTANCE=	7.1170		
DIG CORR - X AXIS	MEAN	1.699787E+00	RMS	1.113582E+00	BETA	3.110945E-02
DIG CORR - Y AXIS	MEAN	6.110589E-01	RMS	5.431911E-01	BETA	1.324083E-02
RADIAL ERROR(RMS)=		1.2390	DRIFT DISTANCE=	3.3134		
EDGE - X AXIS	MEAN	-7.543608E-01	RMS	1.880000E+00	BETA	-4.727377E-02
EDGE - Y AXIS	MEAN	-3.103933E+00	RMS	1.826467E+00	BETA	-1.005520E-01
RADIAL ERROR(RMS)=		2.6211	DRIFT DISTANCE=	10.8888		

TRACKING ERRORS

CENTROID - X AXIS

-.3627	.3905	-.1471	.2569	.7420	.0187	1.6645	1.0631	.4625	.9346
-1.1746	-.0972	-2.5419	.6229	.1153	2.3084	2.7139	-.1171	.7299	1.2936
2.7111	1.9601	3.4797	-1.0812	3.6921	.9674	4.5210	2.6982	3.5080	3.2802
3.0309	3.4181	4.0536	3.9892	5.0916	4.9865	5.0898	1.1376	6.1706	6.7298
5.0379	7.6987	7.4984	7.6579	7.9535	7.3724	6.7242	7.6847	4.3611	7.9997
5.6606	3.3276	1.8090	5.1727	-.7025	1.5215	1.7293	.5756	.5980	-1.4457
4.4627	3.9338	1.0817	2.5039	-.1577	-2.2770	-.8011	-1.8736	.1631	.7814
-1.1460	-2.1369	2.0032	.6522	-.4844	1.0080	-1.4464	-.6132	-1.3463	-1.0335
-1.5006	-1.2800	-.3860	-.6887	-.9215	-.6457	-.9837	-.4903	-.8018	.0521
.0685	1.8049	1.5568	1.7140	1.7491	2.5617	2.3638	1.8945		

CENTROID - Y AXIS

.0947	-1.0456	.5892	.3533	.7339	-.6822	1.5112	2.5567	.7015	.8770
-1.2072	2.2824	-2.8417	1.3716	-2.2004	.3650	4.7720	.8718	.2353	-1.7783
3.0098	-.1191	-.2852	-2.7255	.9822	2.3596	-.0176	3.1922	2.7976	2.7995
2.0638	2.4299	2.0500	3.8342	2.4169	2.6035	2.7848	2.6855	3.4584	2.0289
4.4459	-.4148	1.2072	.0901	2.6342	1.0754	3.7294	2.7168	6.9474	1.0824
-.7670	5.3584	4.9364	-2.7487	-5.8495	-3.7760	-2.6102	-4.5512	-4.8390	-3.3384
-3.0445	-4.8137	-4.4406	-4.5794	-5.3197	-6.2234	-5.5228	-5.9405	-4.5669	-3.5998
-4.4732	-4.4868	-4.1929	-4.3451	-1.1628	-2.6227	-4.7321	-1.8749	-5.5257	-2.3847
-5.2887	-3.7978	-.4839	-5.5313	-3.5382	-.4541	-4.8093	-.5195	-6.0720	-1.4389
-4.3696	-1.5458	-4.8929	-2.6055	-5.5963	-4.6451	-1.5057	-6.4456		

DIG CORR - X AXIS

-.3753	-.5520	-.2133	-.3242	-.3150	-.0071	.2684	.6744	.0590	.2611
.2195	.1565	.2038	.6716	.1032	.0326	-.1100	.0347	.1126	-.0214
-.1381	-.0261	.4574	.7407	.4115	.5569	.8366	1.0096	1.0518	.9377
1.0972	1.0886	1.2560	1.2877	1.2779	1.3851	1.4321	1.6557	1.7710	1.7893
1.5335	2.4433	4.3776	4.2703	4.2992	3.9564	5.5383	6.0384	4.1060	3.6862
3.5842	3.3647	3.5851	2.4184	1.9155	2.1493	1.3891	1.7678	1.4610	1.8503
1.7532	1.6582	1.5031	1.5155	1.4191	1.1375	1.0561	.7500	.7625	.5477
.7316	.8024	.7110	1.2116	1.3177	1.6340	1.7766	1.9911	1.6976	1.9362
2.0426	2.3517	2.2997	2.6759	2.7934	2.7919	3.2190	2.6131	2.6843	2.8253
2.8765	3.5154	3.9663	3.4208	3.8642	3.9341	4.0767	4.1774		

DIG CORR - Y AXIS

-.4096	-.9958	-.3025	-.4404	-.2671	-.1509	.2653	.7336	.1417	.6207
.2057	.2693	.4234	.8760	-.1925	-.4273	-.3834	-.2957	-.3275	-.3125
-.4193	-.2713	.0799	.3724	.1651	.1059	.4064	.7592	.7472	.6298
.6943	.6105	.8372	.8090	.9874	1.0435	1.1039	1.0165	1.1334	1.1159
1.0131	1.1143	1.2472	1.3240	1.1341	1.0963	.9678	.8143	.5002	.4021
-.2159	-.1473	-.3123	-1.3491	-1.3251	-1.0057	-.3660	.9990	-1.4375	1.1041
.6196	.8610	.6649	.9761	.8464	1.0773	1.2841	1.1078	1.6751	1.7585
1.3378	1.3761	1.1012	1.3547	.9774	1.0936	1.0954	1.0098	1.1906	1.3515
1.4927	-1.4607	1.1029	1.0454	1.0134	1.2254	.9056	.9969	1.2922	1.0095
1.1062	.9432	1.0133	1.0619	1.0437	.9905	1.0187	1.0269		

TRACKING ERRORS (Continued)

EDGE - X AXIS

2.0291	-1.0415	2.4734	.4141	.3031	-.5460	.6282	1.3916	-.8167	-.5049
-3.4412	4.9221	-1.8823	.4364	-1.1329	.8715	2.7828	-1.8403	-.8852	.1519
1.7932	.8836	.4325	-3.7060	.5470	-1.8134	.1459	-.5609	1.6299	1.5098
-1.2643	-.0554	.4207	.9896	-.3690	.2976	.0378	-.1937	3.3660	2.2749
-.7663	2.6577	4.0358	4.4532	4.1168	3.6924	1.5915	5.0782	2.3112	2.0991
2.7709	-1.3045	-5.7025	1.3151	.2410	-.2500	-3.4870	-2.7899	-2.7334	-4.6260
3.7890	3.5481	-1.3792	1.3899	-3.9012	-4.9256	-4.2271	-2.0263	-1.7624	-1.7414
-5.2149	-4.1804	-.2030	-1.7646	-1.4463	-2.8009	-3.6944	-2.1052	-2.7937	-3.0607
-2.6974	-3.0193	-4.1101	-1.9481	-4.8122	-3.3854	-8.0107	-1.6503	-4.7208	-2.0004
-1.9451	-.7998	-4.8799	-4.2254	-3.4555	-.8704	-3.8164	-.1145		

EDGE - Y AXIS

1.0553	-.7854	1.3582	.3454	.9658	-.4304	1.0961	-1.7864	1.5034	2.8781
-5.2424	.1209	-4.5700	1.8567	-1.9604	1.6033	1.3194	-3.3286	-1.3036	-.4084
2.5456	1.0176	-.2227	-6.4040	.0106	-1.2046	-2.2894	1.0965	.5292	.9946
.6852	.7707	.4407	1.9274	-.4976	-1.0877	.2971	1.4825	.3133	-1.3095
.4728	-3.3999	-2.5592	-4.2785	-2.4987	-.3674	-2.0648	-2.3186	5.3511	-1.1965
-4.4473	4.5405	4.2356	-7.7063	-3.3681	-4.5838	-4.9622	-4.8603	-4.8440	-1.0833
-7.8593	-6.6691	-6.5302	-5.9946	-6.7633	-4.2871	-4.2345	-4.3806	-7.1176	-5.2541
-8.7701	-8.6908	-6.4703	-8.0877	-7.2325	-4.5436	-7.7634	-5.6353	-5.7530	-7.3695
-6.3578	-7.3437	-3.6997	-6.3833	-9.1432	-4.3238	-11.9290	-4.9015	-3.6913	-4.8295
-9.3690	-5.5070	-11.7888	-6.7259	-10.2998	-6.4561	-5.6899	-13.5216		

FILTERED TRACKER DATA

CENTROID - X AXIS

0.0000	0.0000	.0053	.1150	.3954	.4271	.8377	1.1854	1.0598	.7947
-.0562	-.5420	-1.4333	-1.0763	-.2151	1.2607	2.4544	1.9266	.8057	.4580
1.4897	2.3084	2.9602	1.6239	1.4428	1.4914	2.8356	3.4575	3.6188	3.3764
3.1535	3.1622	3.5624	3.9837	4.5616	4.9909	5.1868	3.6445	3.5676	5.1618
6.2599	6.8900	7.3023	7.6928	7.8855	7.7406	7.2256	7.1022	6.1269	6.2247
6.2905	5.2429	3.0739	2.8129	1.9249	1.1746	.9619	1.0494	.8663	-.2019
.9763	3.1752	3.5249	2.5942	.9795	-.9224	-1.8024	-1.9014	-.9730	.2152
.2536	-.9826	-.6183	.5387	.7839	.5607	-.3044	-.8575	-1.2452	-1.2321
-1.2899	-1.3294	-.9923	-.6266	-.5612	-.6666	-.8400	-.7783	-.7120	-.3910
-.0369	.8316	1.5760	1.9073	1.8499	2.0534	2.3454	2.3081		

CENTROID - Y AXIS

0.0000	0.0000	-.0675	.1208	.5557	.2509	.4275	1.4583	1.8459	1.3733
-.0523	.1319	-.5222	-.2885	-.8276	-.6342	1.5656	2.8066	1.9590	-.4225
-.2122	.6114	.6814	-1.0003	-1.2095	.5047	1.4984	2.1572	2.6075	2.9725
2.6711	2.3177	2.0920	2.7201	3.0447	2.9161	2.6578	2.6108	2.9669	2.8308
3.2597	2.1655	1.0057	.1161	.9326	1.9837	3.0991	3.3493	4.6812	4.1300
1.5861	1.4095	3.5430	2.5275	-2.2189	-5.5569	-5.0725	-3.7974	-3.8147	-4.0465
-3.9934	-4.1795	-4.4941	-4.6637	-4.9147	-5.5703	-5.9280	-5.9774	-5.3767	-4.3386
-3.8570	-4.0793	-4.3710	-4.4210	-3.1331	-2.1026	-2.7778	-3.2105	-4.0730	-3.8223
-4.1262	-4.1807	-2.8375	-2.8630	-3.5659	-2.8901	-2.7769	-2.1317	-3.3411	-3.4095
-3.6106	-2.7932	-3.1861	-3.3575	-4.2761	-4.8703	-3.8220	-3.9138		

DIG CORR - X AXIS

0.0000	0.0000	-.2986	-.4209	-.3628	-.1873	.0305	.4405	.4592	.3036
.1709	.1481	.1747	.3798	.4029	.2202	-.0339	-.1089	-.0053	.0639
-.0081	-.0793	.1093	.4070	.6606	.6145	.6375	.8344	1.0357	1.0669
1.0489	1.0560	1.1505	1.2568	1.3096	1.3438	1.3916	1.5198	1.6862	1.8022
1.7300	1.9298	3.0273	4.1840	4.6709	4.3934	4.5962	5.3999	5.3828	4.4483
3.5290	3.1957	3.3390	3.1108	2.4423	1.9470	1.6215	1.5768	1.5461	1.6596
1.7607	1.7664	1.6338	1.5091	1.4336	1.3025	1.1326	.9071	.7515	.6240
.6201	.7107	.7717	.9471	1.1914	1.4832	1.7139	1.9045	1.8962	1.8643
1.9196	2.1417	2.3245	2.5173	2.7046	2.8244	3.0028	2.9465	2.7692	2.6832
2.7702	3.1241	3.6445	3.8097	3.7949	3.9089	3.9610	4.1251		

DIG CORR - Y AXIS

0.0000	0.0000	-.4680	-.6470	-.4535	-.2171	.0594	.4404	.5149	.5029
.4017	.3181	.3128	.5528	.4242	-.0602	-.4742	-.5117	-.3716	-.2777
-.3178	-.3425	-.1797	.1491	.3213	.2594	.2355	.4592	.7249	.7894
.7217	.6348	.6846	.7830	.9099	1.0118	1.0871	1.0840	1.0850	1.1013
1.0820	1.0726	1.1798	1.2608	1.2696	1.1743	1.0344	.8925	.6825	.4702
.1203	-.1575	-.3159	-.7391	-1.2227	-1.3510	-.9118	.1143	.0552	.1366
.4030	.8741	.8910	.8720	.8561	.9503	1.1321	1.2207	1.4007	1.6361
1.6428	1.4703	1.2239	1.1772	1.1260	1.0862	1.0626	1.0486	1.0937	1.2238
1.4032	1.5047	1.3698	1.1349	.9782	1.0402	1.0217	.9723	1.0610	1.1297
1.1322	1.0351	.9775	.9059	1.0424	1.0414	1.0178	1.0096		

FILTERED TRACKER DATA (Continued)

EDGE - X AXIS

0.0000	0.0000	.9377	1.2147	.9078	-.0019	-.1822	.5445	.5289	-.1412
-1.8360	-.0957	.7906	.7724	-.4498	-.4456	1.0637	.9293	-.3531	-.9651
.2247	1.3275	1.2970	-.9449	-1.7369	-1.6501	-.6601	-.2206	.5897	1.3522
.6930	-.2704	-.4126	.3733	.3505	.0582	-.1130	-.0973	1.2256	2.4940
1.7358	1.1777	2.2347	4.0308	4.7933	4.3803	2.9328	2.9841	3.1550	2.8415
2.4135	.9046	-2.5094	-2.9560	-1.0295	.6333	-.7011	-2.7024	-3.5286	-3.8857
-1.1161	2.5290	2.7437	1.2044	-1.5921	-4.0525	-5.1822	-4.0362	-2.2174	-1.2611
-2.6673	-4.3329	-3.3965	-1.6332	-.7974	-1.6150	-3.0101	-3.3037	-2.9125	-2.6847
-2.7391	-2.8995	-3.4227	-3.1771	-3.4960	-3.7213	-5.5305	-5.0532	-4.2084	-2.8550
-2.9725	-1.2737	-2.3446	-3.9441	-4.5150	-2.9583	-2.2223	-1.4378		

EDGE - Y AXIS

0.0000	0.0000	.4437	.6444	.8516	.3900	.3482	-.3774	-.1000	1.3582
-.2109	-1.6381	-3.2517	-1.7332	-.6694	.5432	1.1973	-.2224	-1.8012	-1.8766
.3061	1.8667	1.4421	-.2562	-3.5542	-2.4614	-1.2974	-.2664	.4900	1.0381
1.0004	.8063	.5728	1.0030	.7625	-.2267	-.6516	.2373	.9401	.2106
-.3659	-1.6135	-2.6154	-3.6878	-3.6021	-2.1095	-1.1351	-1.4209	.7184	1.6219
-.6804	-.6379	2.2064	.3052	-3.5194	-5.7823	-5.5257	-4.8815	-4.6557	-3.2969
-4.1625	-6.0492	-7.3152	-6.9110	-6.3936	-5.4630	-4.5239	-4.0332	-5.1805	-6.0469
-7.3052	-8.3899	-8.1640	-7.6384	-7.2672	-6.2089	-6.1084	-6.1507	-6.0969	-6.3977
-6.6748	-7.0327	-5.8696	-5.2530	-6.6399	-6.9175	-8.4937	-8.0483	-5.8730	-3.9584
-5.6019	-7.1118	-9.2697	-9.2122	-9.2558	-8.1353	-6.6448	-8.4682		

SPECTRAL DENSITY CENTROID - X AXIS

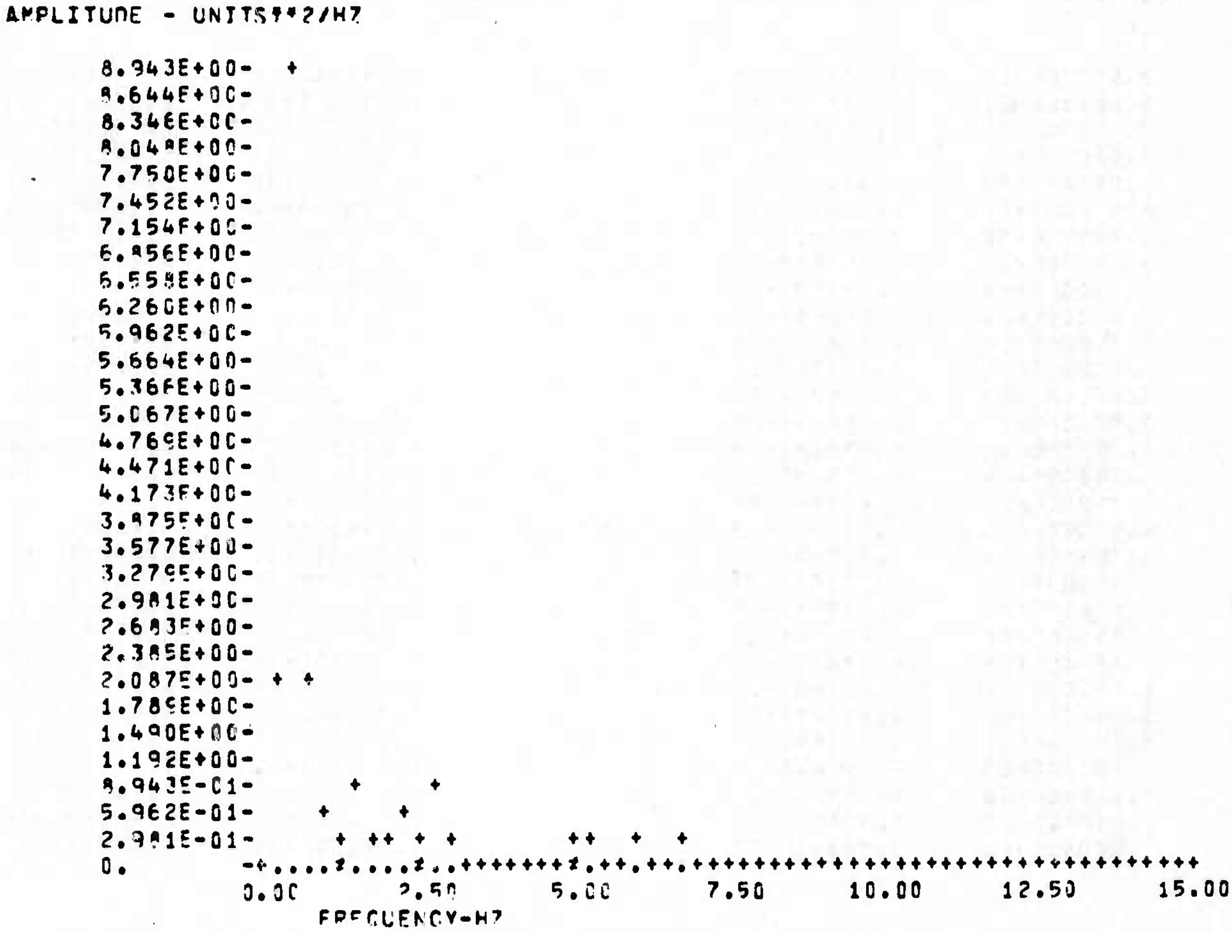
FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	5.98252E+00	7.75000E+00	1.93581E-02
5.00000E-01	1.27320E+01	8.00000E+00	3.65507E-02
7.50000E-01	3.27849E-01	8.25000E+00	1.90946E-02
1.00000E+00	4.01396E-01	8.50000E+00	1.11790E-02
1.25000E+00	1.17079E+00	8.75000E+00	7.58391E-03
1.50000E+00	1.00695E-02	9.00000E+00	5.06378E-03
1.75000E+00	5.89901E-01	9.25000E+00	5.55693E-03
2.00000E+00	3.09754E-01	9.50000E+00	1.13519E-03
2.25000E+00	3.12095E-01	9.75000E+00	9.95820E-03
2.50000E+00	1.72901E-02	1.00000E+01	1.00007E-03
2.75000E+00	7.35543E-01	1.02500E+01	2.08767E-04
3.00000E+00	5.44219E-02	1.05000E+01	9.70243E-03
3.25000E+00	2.69330E-01	1.07500E+01	7.28459E-03
3.50000E+00	9.83879E-02	1.10000E+01	7.17532E-03
3.75000E+00	3.37127E-02	1.12500E+01	5.53350E-04
4.00000E+00	1.33737E-03	1.15000E+01	1.47598E-03
4.25000E+00	1.50522E-01	1.17500E+01	1.57399E-03
4.50000E+00	3.22836E-01	1.20000E+01	4.41868E-03
4.75000E+00	3.29169E-02	1.22500E+01	8.74931E-03
5.00000E+00	1.99381E-01	1.25000E+01	2.49138E-03
5.25000E+00	2.14963E-01	1.27500E+01	2.31047E-03
5.50000E+00	2.10681E-02	1.30000E+01	2.47222E-03
5.75000E+00	1.23187E-02	1.32500E+01	4.93843E-03
6.00000E+00	7.89310E-03	1.35000E+01	1.37775E-03
6.25000E+00	4.99861E-02	1.37500E+01	2.24246E-03
6.50000E+00	2.79121E-02	1.40000E+01	3.80743E-04
6.75000E+00	4.25550E-02	1.42500E+01	9.51912E-03
7.00000E+00	1.92757E-02	1.45000E+01	5.65622E-03
7.25000E+00	9.17869E-03	1.47500E+01	2.69284E-03
7.50000E+00	3.65406E-03	1.50000E+01	2.12341E-03

SPECTRAL DENSITY CENTROID - X AXIS

SPECTRAL DENSITY CENTROID - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.56092E+00
5.00000E-01	8.94253E+00
7.50000E-01	2.19906E+00
1.00000E+00	7.40167E-01
1.25000E+00	1.76103E-01
1.50000E+00	8.48024E-01
1.75000E+00	7.54005E-01
2.00000E+00	1.74225E-01
2.25000E+00	5.28104E-01
2.50000E+00	2.13022E-01
2.75000E+00	9.47339E-01
3.00000E+00	3.31538E-01
3.25000E+00	2.60858E-02
3.50000E+00	8.13439E-02
3.75000E+00	3.57424E-02
4.00000E+00	9.96679E-02
4.25000E+00	5.49974E-02
4.50000E+00	1.29243E-02
4.75000E+00	1.20933E-01
5.00000E+00	3.62951E-01
5.25000E+00	2.02092E-01
5.50000E+00	1.04383E-01
5.75000E+00	3.73049E-02
6.00000E+00	1.54350E-01
6.25000E+00	1.64152E-03
6.50000E+00	1.04658E-01
6.75000E+00	3.46601E-01
7.00000E+00	4.62310E-02
7.25000E+00	5.02361E-02
7.50000E+00	7.21874E-02
7.75000E+00	1.05352E-01
8.00000E+00	4.81519E-02
8.25000E+00	3.51010E-02
8.50000E+00	4.46901E-03
8.75000E+00	1.70475E-02
9.00000E+00	6.03245E-03
9.25000E+00	3.92492E-03
9.50000E+00	7.21755E-03
9.75000E+00	1.35030E-03
1.00000E+01	6.40819E-03
1.02500E+01	5.23079E-03
1.05000E+01	4.69358E-03
1.07500E+01	9.80957E-03
1.10000E+01	2.56335E-03
1.12500E+01	3.52677E-04
1.15000E+01	9.81991E-03
1.17500E+01	3.21391E-04
1.20000E+01	3.35034E-03
1.22500E+01	1.18150E-02
1.25000E+01	1.13829E-03
1.27500E+01	9.93091E-03
1.30000E+01	1.03703E-02
1.32500E+01	5.26640E-04
1.35000E+01	5.25361E-03
1.37500E+01	2.60371E-03
1.40000E+01	8.93144E-03
1.42500E+01	3.43374E-03
1.45000E+01	3.53522E-03
1.47500E+01	8.19682E-03
1.50000E+01	2.92538E-03

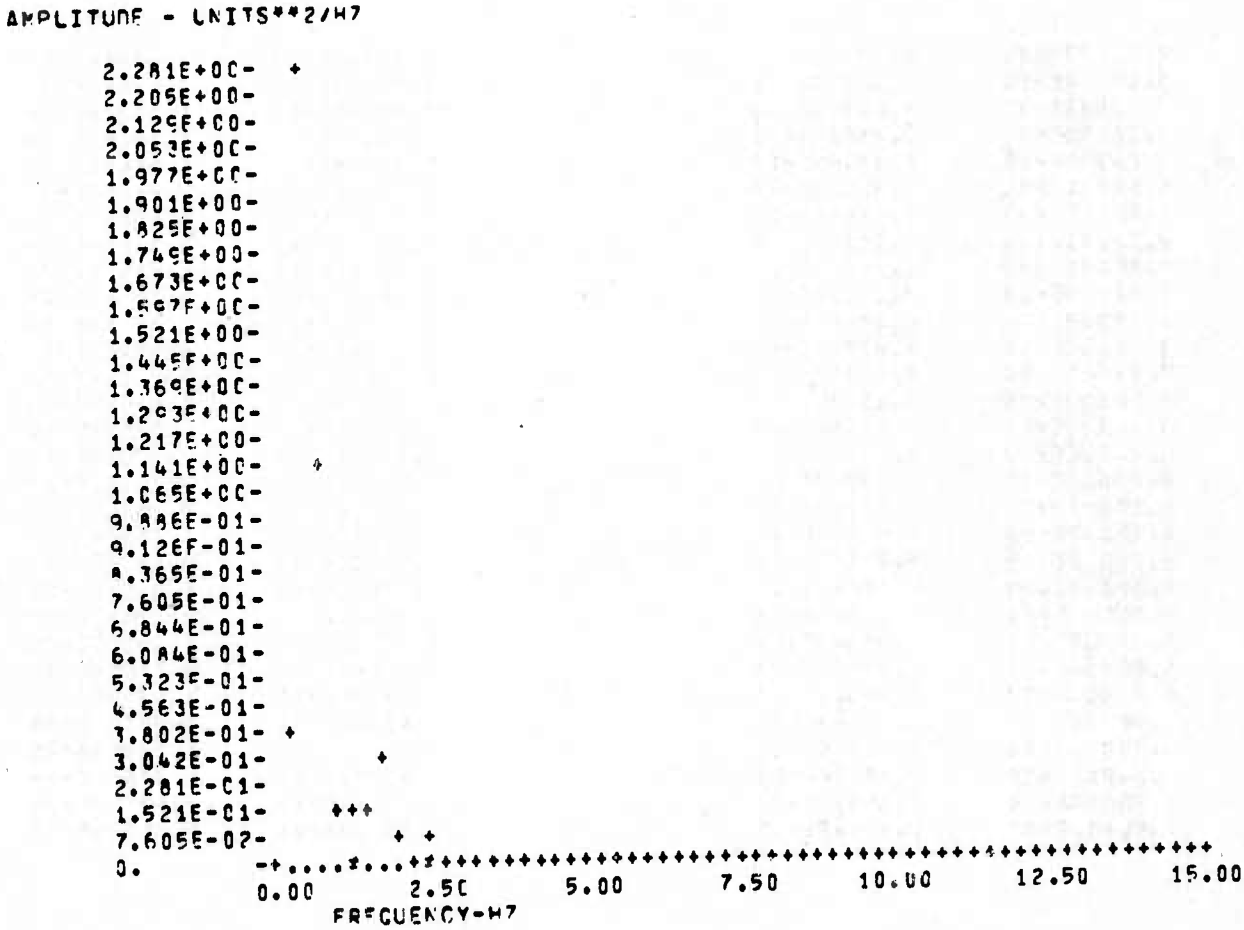
SPECTRAL DENSITY CENTROID - Y AXIS



SPECTRAL DENSITY DIG CORR - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	3.73331E-01	7.75000E+00	1.02406E-03
5.00000E-01	2.29142E+00	8.00000E+00	1.40140E-03
7.50000E-01	1.14112E+00	8.25000E+00	5.75109E-05
1.00000E+00	1.77453E-01	8.50000E+00	9.44405E-04
1.25000E+00	1.43425E-01	8.75000E+00	1.34402E-04
1.50000E+00	1.30408E-01	9.00000E+00	7.33731E-04
1.75000E+00	3.27092E-01	9.25000E+00	3.89915E-05
2.00000E+00	9.26708E-02	9.50000E+00	4.35891E-04
2.25000E+00	1.88859E-02	9.75000E+00	4.99791E-04
2.50000E+00	3.91666E-02	1.00000E+01	1.20423E-04
2.75000E+00	4.01863E-03	1.02500E+01	1.19821E-04
3.00000E+00	3.72125E-02	1.05000E+01	2.74995E-05
3.25000E+00	5.86627E-03	1.07500E+01	3.58549E-04
3.50000E+00	1.06698E-02	1.10000E+01	4.31818E-04
3.75000E+00	1.59136E-02	1.12500E+01	3.54192E-04
4.00000E+00	5.65049E-03	1.15000E+01	5.80867E-04
4.25000E+00	6.47386E-04	1.17500E+01	5.61796E-05
4.50000E+00	2.30845E-03	1.20000E+01	3.73661E-04
4.75000E+00	9.31814E-05	1.22500E+01	2.99279E-04
5.00000E+00	9.70154E-03	1.25000E+01	3.71246E-04
5.25000E+00	9.12009E-03	1.27500E+01	1.45942E-04
5.50000E+00	7.62956E-03	1.30000E+01	8.46191E-05
5.75000E+00	8.62671E-03	1.32500E+01	9.10838E-05
6.00000E+00	1.61263E-02	1.35000E+01	4.17034E-04
6.25000E+00	2.41328E-02	1.37500E+01	4.02398E-04
6.50000E+00	4.74309E-03	1.40000E+01	1.36401E-04
6.75000E+00	9.06244E-03	1.42500E+01	1.31339E-04
7.00000E+00	4.00384E-03	1.45000E+01	1.16863E-05
7.25000E+00	6.27712E-03	1.47500E+01	2.08589E-04
7.50000E+00	3.89144E-03	1.50000E+01	4.16898E-04

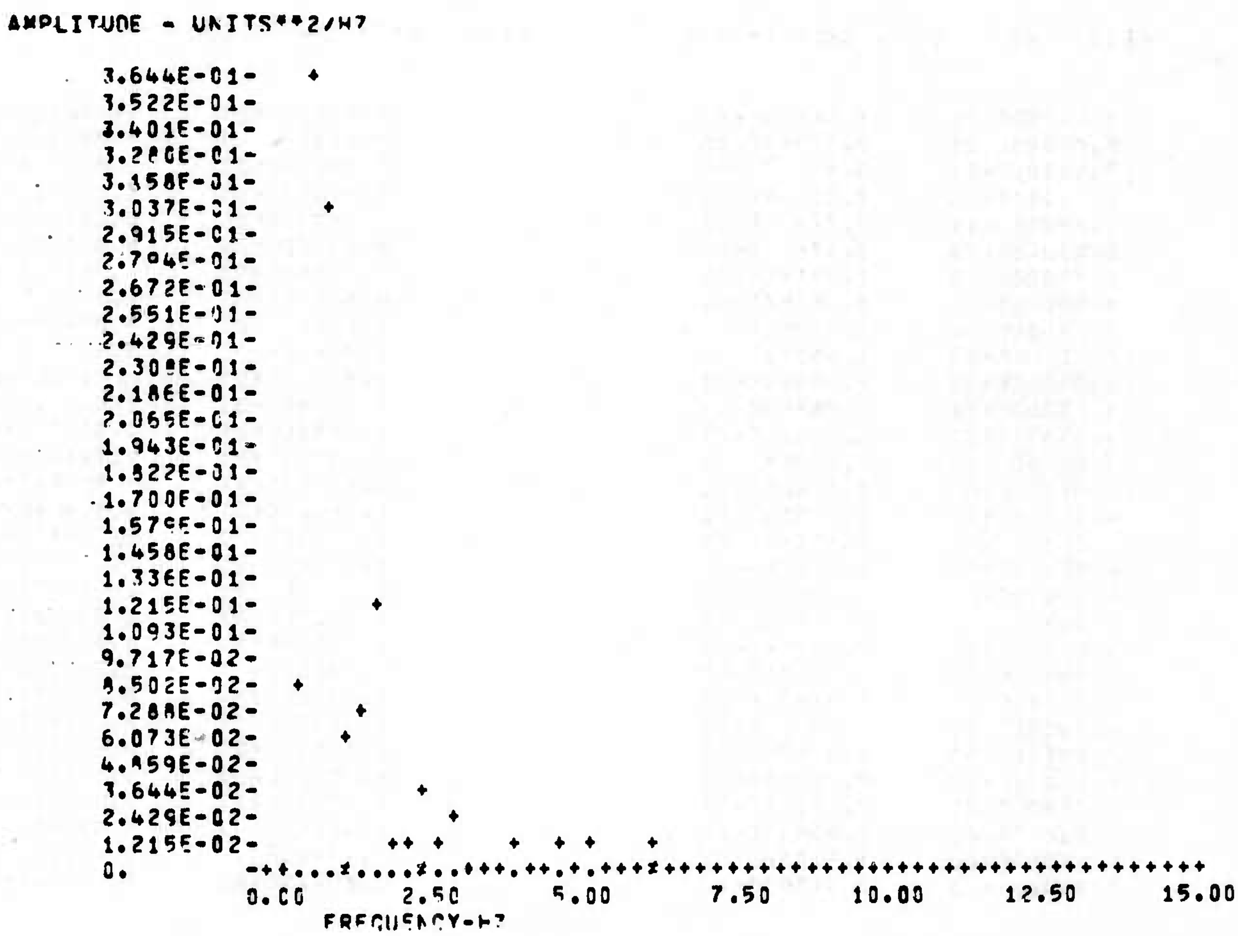
SPECTRAL DENSITY CIG CORR - X AXIS



SPECTRAL DENSITY DIG CORR - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.59947E-03	7.75000E+00	1.03314E-04
5.00000E-01	9.26333E-02	8.00000E+00	4.49459E-04
7.50000E-01	3.64390E-01	8.25000E+00	1.36328E-04
1.00000E+00	2.98131E-01	8.50000E+00	7.43452E-04
1.25000E+00	5.58492E-02	8.75000E+00	9.60430E-06
1.50000E+00	7.80513E-02	9.00000E+00	4.85267E-04
1.75000E+00	1.18165E-01	9.25000E+00	5.00220E-04
2.00000E+00	9.25354E-03	9.50000E+00	5.06179E-04
2.25000E+00	1.25742E-02	9.75000E+00	1.49992E-04
2.50000E+00	3.54032E-02	1.00000E+01	1.17649E-04
2.75000E+00	1.13796E-02	1.02500E+01	3.32844E-04
3.00000E+00	2.43096E-02	1.05000E+01	4.43024E-05
3.25000E+00	3.81383E-03	1.07500E+01	2.57148E-04
3.50000E+00	1.65735E-03	1.10000E+01	1.08425E-04
3.75000E+00	8.61556E-05	1.12500E+01	1.02578E-04
4.00000E+00	1.21360E-02	1.15000E+01	6.28925E-05
4.25000E+00	5.09079E-03	1.17500E+01	2.19611E-04
4.50000E+00	7.25602E-04	1.20000E+01	9.18284E-06
4.75000E+00	8.52164E-03	1.22500E+01	1.34308E-04
5.00000E+00	8.57567E-04	1.25000E+01	2.52728E-04
5.25000E+00	9.12574E-03	1.27500E+01	8.34178E-05
5.50000E+00	4.70635E-03	1.30000E+01	2.11417E-04
5.75000E+00	1.36069E-04	1.32500E+01	1.49677E-04
6.00000E+00	1.02002E-03	1.35000E+01	5.11710E-05
6.25000E+00	8.56002E-03	1.37500E+01	1.42455E-04
6.50000E+00	4.24858E-03	1.40000E+01	6.87305E-05
6.75000E+00	1.56546E-03	1.42500E+01	6.02853E-05
7.00000E+00	3.77136E-03	1.45000E+01	3.87873E-04
7.25000E+00	2.19376E-03	1.47500E+01	9.43753E-05
7.50000E+00	2.16647E-03	1.50000E+01	2.97889E-04

SPECTRAL DENSITY DIG CORR - Y AXIS

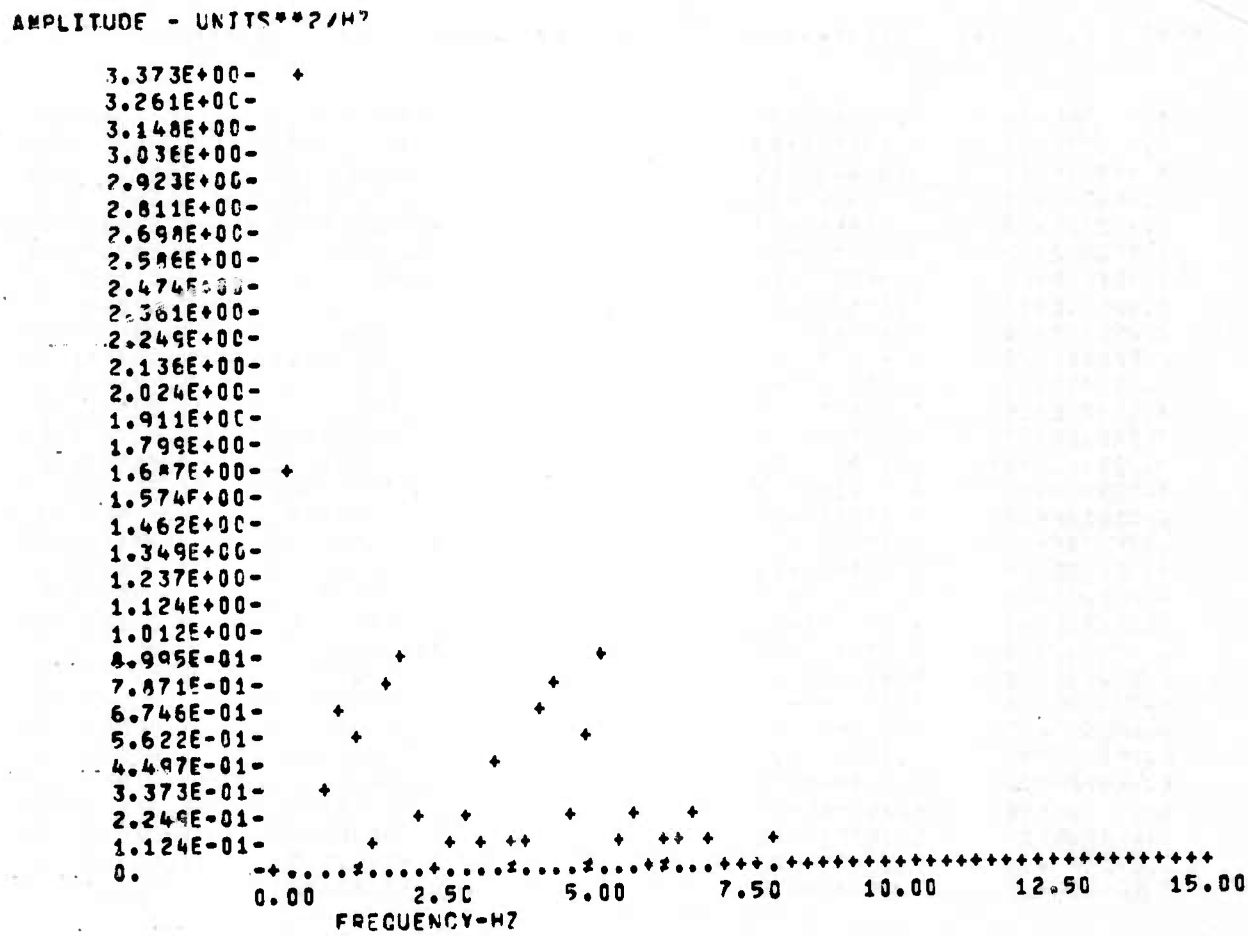


SPECTRAL DENSITY EDGE - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.66550E+00
5.00000E-01	3.37308E+00
7.50000E-01	3.88387E-01
1.00000E+00	7.10841E-01
1.25000E+00	5.77836E-01
1.50000E+00	1.47469E-01
1.75000E+00	7.39368E-01
2.00000E+00	8.79757E-01
2.25000E+00	[illegible]
2.50000E+00	1.98078E-02
2.75000E+00	1.65344E-01
3.00000E+00	1.89294E-01
3.25000E+00	1.50951E-01
3.50000E+00	4.19562E-01
3.75000E+00	1.15425E-01
4.00000E+00	1.31593E-01
4.25000E+00	6.80748E-01
4.50000E+00	7.67149E-01
4.75000E+00	1.71604E-01
5.00000E+00	5.44756E-01
5.25000E+00	9.20804E-01
5.50000E+00	9.58438E-02
5.75000E+00	1.77871E-01
6.00000E+00	1.30575E-02
6.25000E+00	1.07455E-01
6.50000E+00	9.21925E-02
6.75000E+00	2.60196E-01
7.00000E+00	6.40547E-02
7.25000E+00	1.52778E-02
7.50000E+00	7.97893E-03

FREQ - HZ	AMP - UNITS**2/HZ
7.75000E+00	1.32011E-02
8.00000E+00	5.85932E-02
8.25000E+00	1.50856E-02
8.50000E+00	1.63111E-02
8.75000E+00	1.40858E-02
9.00000E+00	8.82313E-03
9.25000E+00	1.25130E-02
9.50000E+00	2.17524E-03
9.75000E+00	2.29972E-02
1.00000E+01	1.93516E-03
1.02500E+01	4.24816E-04
1.05000E+01	1.04594E-03
1.07500E+01	8.97035E-03
1.10000E+01	4.74100E-03
1.12500E+01	2.85556E-04
1.15000E+01	5.94964E-03
1.17500E+01	6.27927E-04
1.20000E+01	8.08558E-04
1.22500E+01	1.92627E-02
1.25000E+01	8.69378E-04
1.27500E+01	4.53236E-04
1.30000E+01	1.64314E-03
1.32500E+01	9.70071E-03
1.35000E+01	2.26626E-03
1.37500E+01	9.04482E-04
1.40000E+01	4.11686E-03
1.42500E+01	1.24482E-02
1.45000E+01	6.85100E-04
1.47500E+01	5.43716E-03
1.50000E+01	2.22158E-02

SPECTRAL DENSITY EDGE - X AXIS

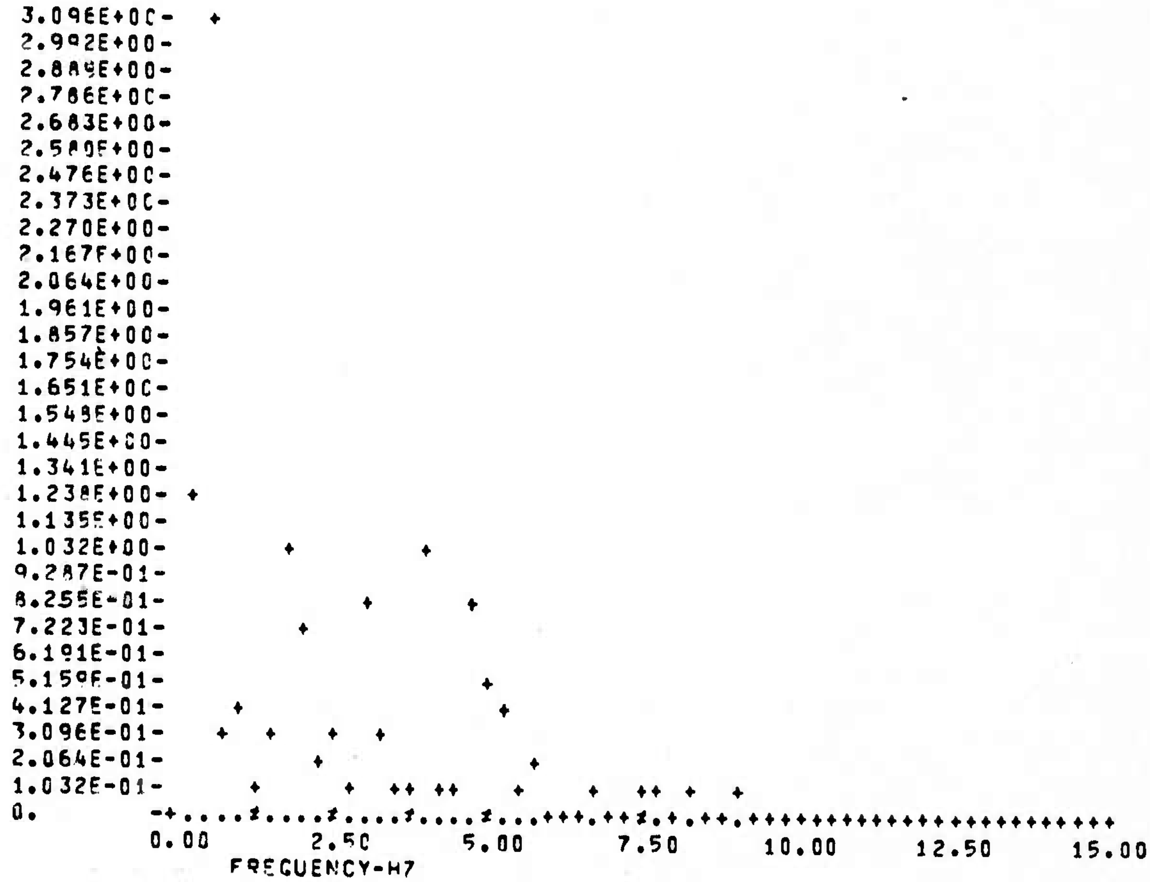


SPECTRAL DENSITY EDGE - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.25903E+00
5.00000E-01	3.09558E+00
7.50000E-01	3.07440E-01
1.00000E+00	3.90366E-01
1.25000E+00	1.41955E-01
1.50000E+00	3.20583E-01
1.75000E+00	9.84771E-01
2.00000E+00	7.23530E-01
2.25000E+00	2.44495E-01
2.50000E+00	3.29388E-01
2.75000E+00	8.27051E-02
3.00000E+00	7.96887E-01
3.25000E+00	2.69929E-01
3.50000E+00	1.54543E-01
3.75000E+00	8.49011E-02
4.00000E+00	9.87102E-01
4.25000E+00	1.42039E-01
4.50000E+00	1.31798E-01
4.75000E+00	8.12443E-01
5.00000E+00	4.73199E-01
5.25000E+00	3.72281E-01
5.50000E+00	9.64898E-02
5.75000E+00	2.37160E-01
6.00000E+00	2.10569E-02
6.25000E+00	2.22780E-03
6.50000E+00	4.81599E-02
6.75000E+00	6.64986E-02
7.00000E+00	1.06710E-02
7.25000E+00	2.07223E-03
7.50000E+00	7.85438E-02
7.75000E+00	1.51383E-01
8.00000E+00	4.34204E-02
8.25000E+00	1.13434E-01
8.50000E+00	4.36022E-02
8.75000E+00	1.58084E-02
9.00000E+00	1.03369E-01
9.25000E+00	5.61255E-03
9.50000E+00	1.42048E-04
9.75000E+00	1.33039E-02
1.00000E+01	1.33776E-02
1.02500E+01	1.52661E-02
1.05000E+01	9.03220E-04
1.07500E+01	7.36780E-03
1.10000E+01	3.26283E-03
1.12500E+01	1.34404E-02
1.15000E+01	1.91086E-02
1.17500E+01	1.98178E-02
1.20000E+01	3.31009E-03
1.22500E+01	1.28836E-03
1.25000E+01	4.03896E-03
1.27500E+01	7.24392E-03
1.30000E+01	2.51933E-02
1.32500E+01	3.76491E-04
1.35000E+01	1.06198E-02
1.37500E+01	1.42589E-02
1.40000E+01	7.52954E-03
1.42500E+01	2.22103E-03
1.45000E+01	8.18438E-03
1.47500E+01	2.64318E-03
1.50000E+01	3.24809E-03

SPECTRAL DENSITY EDGE - Y AXIS

AMPLITUDE - UNITS**2/HZ



CDC 6600 CSP Printout V

Reference Program: Processing of IR data for stationary target in narrow field of view.

Tracking Program: Run no. 88 using above referenced data

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DIGITAL CORRELATION TRACKER - REFERENCING PROGRAM

 PROCESS 99 PICTURES
SEARCH WINDOW IS 16 X  16
STARTING TARGET COORDINATES ARE (41,41)
TAPE OUTPUT OPTION IS 1

CONTRAST ......NEG
```

COORDINATE ERROR ANALYSIS

STARTING COORDINATES * X= 41.00
Y= 41.00

****

NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR
1	0.00	0.00	2	.13	-.06	3	-.44	-.06
4	.31	-.06	5	-.25	0.00	6	-.25	.06
7	0.00	.13	8	.25	.13	9	-.13	.13
10	-.25	.13	11	-.31	.13	12	-.50	.13
13	-.13	.13	14	.31	.06	15	-.19	.06
16	-.13	.06	17	.06	.13	18	.31	.13
19	-.13	.13	20	.06	.06	21	0.00	.06
22	.13	.06	23	-.19	.06	24	-.44	.13
25	-.31	.13	26	-.63	.19	27	-.13	.19
28	.13	.13	29	-.31	.06	30	-.44	0.00
31	-.13	0.00	32	.06	0.00	33	-.31	.06
34	.13	.06	35	-.44	.13	36	-.75	.13
37	-.25	.13	38	.06	.06	39	-.38	.06
40	-.44	.06	41	-.56	.06	42	-.06	0.00
43	-.38	-.06	44	-.56	-.06	45	-.19	-.06
46	-.81	-.06	47	-.81	-.06	48	0.00	-.06
49	-.44	-.06	50	-.56	0.00	51	-.25	.06
52	-.06	.06	53	-.44	.06	54	-.63	.06
55	-.25	.06	56	-.81	.06	57	-.38	.06
58	0.00	.06	59	-.50	.06	60	-.56	.13
61	-.31	.13	62	-.06	.13	63	-.44	.13
64	-.25	.13	65	-.06	.19	66	-.13	.19
67	-.50	.19	68	0.00	.13	69	-.50	.13
70	-.50	.13	71	-.56	.13	72	-.06	.13
73	-.44	.13	74	-.56	.13	75	-.19	.13
76	-.06	.13	77	-.31	.13	78	.06	.06
79	-.44	.06	80	-.44	.13	81	-.63	.13
82	0.00	.06	83	-.44	.06	84	-.56	0.00
85	-.63	.06	86	-.13	.13	87	-.44	.19
88	0.00	.13	89	-.56	.19	90	-.88	.13
91	-.38	.19	92	-.06	.19	93	-.50	.19
94	-.56	.19	95	-.31	.13	96	-.13	.13
97	-.44	.13	98	0.00	.13	99	-.31	.19

SIGNAL/NOISE DETERMINATION

SAMPLE	SIGNAL LEVEL	NOISE LEVEL	S/N
1	13.36	1.81	7.40
2	13.39	1.71	7.83
3	13.34	1.77	7.53
4	13.34	1.78	7.49
5	13.26	2.16	6.13
6	13.37	2.04	6.54
7	13.37	2.19	6.11
8	13.35	1.83	7.31
9	13.25	2.22	5.97

RESULTANT SIGNAL/NOISE = 6.921

TRACKING RUN NO. 68

```
X DIMENSION = 16      Y DIMENSION = 16
X CENTER = 32         Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
  0 FRAMES SKIPPED,  99 FRAMES PROCESSED
FREQUENCY =  30.00
5 INPUT BITS USED
ICOLPS = 0     IOFF = 0
SCALOF =   4.00     SFACX =   5.00     SFACY =   5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT 10 FRAMES(SKIP)
LINEAR PROCESSING ABOVE THRESHOLD OF - 20 FOR CENTROID TRACKER
```

```
CENTROID - X AXIS  GAIN =    1.01916

CENTROID - Y AXIS  GAIN =     .99941

DIG CORR - X AXIS  GAIN =    1.00000

DIG CORR - Y AXIS  GAIN =    1.00000

EDGE - X AXIS      GAIN =     .99466

EDGE - Y AXIS      GAIN =     .98813
```

SAMPLE NO. 98   RUN NO. 88

INPUT PICTURE (X OFFSET = -2, Y OFFSET = -4)

INPUT DATA DIVIDED BY 2

5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	5
6	6	6	5	5	5	6	6	5	5	6	6	6	5	6	5	5	6	5	5	6	5	5	5	5	5	5	5	5	6	5	5
5	5	5	5	6	6	6	5	5	5	5	6	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	6	6	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	5	6	5	6	5	5	5	5	6	6	5	5	5	5	5	6	6	5	5	5	6	5	5	5	5	5	5	6
5	5	5	6	6	5	6	5	6	5	5	6	6	6	6	5	6	6	5	5	5	5	5	5	5	6	5	5	5	5	5	5
5	5	6	5	5	5	5	6	6	6	6	6	5	5	6	5	6	6	5	5	5	5	5	5	5	5	5	5	5	6	5	5
6	5	5	5	6	6	5	6	6	6	6	6	5	6	6	6	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	5	5	5	5	6	6	6	6	6	5	6	6	6	6	6	6	5	5	6	5	6	5	5	5	5	5	5	5	5	5
5	5	6	5	6	5	5	6	6	6	6	6	7	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	6	5
5	5	5	5	6	5	5	6	6	6	6	8	8	1	1	8	9	9	9	7	5	5	5	6	5	5	5	5	5	5	5	5
5	6	5	5	6	6	5	6	7	9	1	5	5	5	5	5	5	2	6	5	5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	5	5	6	5	6	6	7	3	5	5	5	5	5	5	8	8	6	6	5	5	5	5	5	5	5	5	5	5	5
5	5	6	5	6	5	5	6	7	9	1	5	5	5	5	5	5	3	7	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	5	6	6	6	6	8	5	5	5	5	5	5	5	8	8	6	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	6	6	6	6	6	6	8	5	5	5	5	5	5	3	7	6	5	5	5	5	5	5	5	5	5	5	5	5
5	5	6	5	5	5	5	6	6	6	7	8	8	8	8	8	7	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	6	5	6	6	5	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	6	5	6	5	5	5	5
6	5	5	5	5	5	5	6	5	5	5	6	6	5	6	6	5	5	6	6	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	5	5	6	6	6	6	6	6	6	6	5	6	5	5	6	6	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	6	5	6	5	6	5	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	5	5	5	5	5	5	5	6	6	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6
5	6	5	5	5	5	5	6	5	5	5	6	5	5	6	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	5	5	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	6	5	5	5	6	5	5	5	5
6	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	6	6	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	6	6	5	6	5	5	6	5	6	6	5	6	6	5	5	5	5	5	5	5	6	5	5	5	6	5	5	5
5	6	5	5	5	5	5	6	5	5	5	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5
6	5	5	5	5	5	6	5	5	5	5	5	5	5	6	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	5	5	5	6	5	5	6	5	6	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6
5	5	5	5	5	5	6	6	6	6	5	6	5	5	5	6	5	5	6	6	5	6	5	5	5	5	5	5	5	5	5	6
5	5	5	5	6	6	5	5	5	6	5	5	6	6	5	6	6	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5
6	5	5	5	5	5	5	6	5	6	5	5	6	5	6	5	6	6	5	5	5	5	5	5	5	6	5	6	5	5	5	6

SAMPLE NO. 98 RUN NO. 88

VIDEO GRADIENTS

INPUT DATA DIVIDED BY 2

```
. . . . . . . . . . . . . . . . 1 . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . 1 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . 1 . . . . . . . . . . . 1 . . . . . . .
. . . . . . . . . . . . . . . . . 1 . . . . . . . . . . . . . .
. . . . . . . . . . . . 1 . . . . 1 . . . . 1 . . . . . . . . .
. . . . . . . . . . 1 2 1 . . . . . . . . . . . . . . . . . 1 .
. . . . . . . . . . 1 4 5 6 7 6 5 5 3 1 . . . . . . . . . . . .
1 . . . . . . 1 4 6 █ █ 7 6 7 8 7 4 4 1 . . 1 1 . . . . . . . .
. . . . . . . 1 3 5 5 . . . . . 6 5 3 1 . . . . . . . . . . . .
. . . . . . . 1 3 6 5 . . . . . 6 6 3 1 1 . . . . . . . . . . .
. . . . . . . 1 3 7 4 . . . . . 6 6 3 1 . . . . . . . . . . . .
. . 1 . . . . . 2 8 7 . . . . . 6 6 2 1 . . . . . . . . . . . .
. . . 1 1 . 1 . . 2 8 Z █ Z Z Z Z 8 1 1 . . . . . . . . . . . .
. . . . . . . . . 1 2 3 3 3 3 3 1 . . . . . . . . . . . . . . .
. . . . . . . . . . . . . 1 . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . 1 . 1 . . . . . . . . . . . . .
. . . . . . . . . . . . . . . 1 1 . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. 1 . . . . . . . . . . . . . . . . 1 . . . . . . . . . . . . .
1 1 . . . . . . . . . 1 . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . 1 . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . 1 . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

SAMPLE NO. 98 RUN NO. 88

EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

```
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . 1 1 1 1 1 1 1 . . . . . . . . . . . . . .
. . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . .
. . . . . . . . . 1 1 . . . . . 1 1 . . . . . . . . . . . . . .
. . . . . . . . . 1 1 . . . . . 1 1 . . . . . . . . . . . . . .
. . . . . . . . . 1 1 . . . . . 1 1 . . . . . . . . . . . . . .
. . . . . . . . . 1 1 . . . . . 1 1 . . . . . . . . . . . . . .
. . . . . . . . . . 1 1 1 1 1 1 1 1 . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

SAMPLE NO. 98 RUN NO. 88

DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	5
6	6	6	5	5	5	6	6	5	5	6	6	6	5	6	5	5	6	5	5	6	5	5	5	5	5	5	5	5	6	5	5
5	5	5	5	6	6	6	5	5	5	5	6	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	6	6	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	5	6	5	6	5	5	5	5	6	6	5	5	5	5	5	6	6	5	5	5	6	5	5	5	5	5	5	6
5	5	5	6	6	5	6	5	6	5	5	6	6	6	6	5	6	6	5	5	5	5	5	5	5	6	5	5	5	5	5	5
5	5	6	5	5	5	5	6	6	6	6	6	5	5	6	5	6	6	5	5	5	5	5	5	5	5	5	5	5	6	5	5
6	5	5	5	6	6	5	6	6	6	6	6	5	6	6	6	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	5	5	5	5	6	6	6	6	6	5	6	6	6	6	6	6	5	5	6	5	6	5	5	5	5	5	5	5	5	5
5	5	6	5	6	5	5	6	6	6	6	6	7	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	6	5
5	5	5	5	6	5	5	6	6	6	6	8	8	1	1	8	9	9	9	7	5	5	5	6	5	5	5	5	5	5	5	5
5	6	5	5	6	6	5	6	7	9	1	8	8	8	8	8	8	2	6	5	5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	5	5	6	5	6	6	7	3	8	8	8	8	8	8	8	8	6	6	5	5	5	5	5	5	5	5	5	5	5
5	5	6	5	6	5	5	6	7	9	1	8	8	8	8	8	8	3	7	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	5	6	6	6	6	8	8	8	8	8	8	8	8	8	8	6	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	6	6	6	6	6	6	8	8	8	8	8	8	8	3	7	6	5	5	5	5	5	5	5	5	5	5	5	5
5	5	6	5	5	5	5	6	6	6	7	8	8	8	8	8	7	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	6	5	6	6	5	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	6	5	6	5	5	5	5
6	5	5	5	5	5	5	6	5	5	5	6	6	5	6	6	5	5	6	6	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	5	5	6	6	6	6	6	6	6	6	5	6	5	5	6	6	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	6	5	6	5	6	5	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	5	5	5	5	5	5	5	6	6	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6
5	6	5	5	5	5	5	6	5	5	5	6	5	5	6	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	6	5	5	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	6	5	5	5	6	5	5	5	5
6	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	6	6	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	6	6	5	6	5	5	6	5	6	6	5	6	6	5	5	5	5	5	5	5	6	5	5	5	6	5	5	5
5	6	5	5	5	5	5	6	5	5	5	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5
6	5	5	5	5	5	6	5	5	5	5	5	5	5	6	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	5	5	5	6	5	5	6	5	6	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6
5	5	5	5	5	5	6	6	6	6	5	6	5	5	5	6	5	5	6	6	5	6	5	5	5	5	5	5	5	5	5	6
5	5	5	5	6	6	5	5	5	6	5	5	6	6	5	6	6	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5
6	5	5	5	5	5	5	6	5	6	5	5	6	5	6	5	6	6	5	5	5	5	5	5	5	6	5	6	5	5	5	6

SAMPLE NO. 98   RUN NO. 88

CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . 5 1 1 8 . . . . . . . . . . . . . . . .
. . . . . . . . . . 1 5 5 5 5 5 5 2 . . . . . . . . . . . . . .
. . . . . . . . . . 3 5 5 5 5 5 5 8 . . . . . . . . . . . . . .
. . . . . . . . . . 1 5 5 5 5 5 5 3 . . . . . . . . . . . . . .
. . . . . . . . . . 5 5 5 5 5 5 5 8 . . . . . . . . . . . . . .
. . . . . . . . . . . 5 5 5 5 5 5 3 . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 98   RUN NO. 88

CORRELATION REFERENCE MATRIX

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10111111111111111010111110101010
11111110111111111111111110101011
11111010111110111111111111111111
11111011111110111111111111111111
10101011111112111111111111101010
11111111212131313131212111101010
11111112131518202021201716131110
11111418263131313131302516121210
11111218273131313131292217141211
10121518263131313131312617111011
10101219273031313131312417131110
10101112182730303030302718121010
10111112141717161515141110101010
10111111101112121212111111111010
11111111111010101212111111111010
11111111111010101010111110101010
```

TRACKING ERRORS

EDGE ERRORS XM= -1.9432   YM= -4.3388   XC= -.2557   YC= -.1513

CENTROID ERRORS XM= -2.0394   YM= -4.0575   XC= -.3519   YC= .1300

CORRELATION ERRORS XM= -2.0340   YM= -3.9756   XC= -.3465   YC= .2119

FRAME OFFSETS -2 -4   INPUT INCR. ERRORS   .3125   -.1875

FINAL SEARCH CORRELATIONS -

7.34E+02   5.62E+02   7.44E+02   4.92E+02   3.20E+02   5.00E+02   7.18E+02   5.58E+02   7.44E+02

STATISTICAL DATA

	RESOLUTION ELEMENTS				REGRESSION COEF	
CENTROID - X AXIS	MEAN	-2.338841E-01	RMS	8.189693E-02	BETA	-4.209288E-03
CENTROID - Y AXIS	MEAN	3.959850E-02	RMS	6.612397E-02	BETA	1.219636E-03
RADIAL ERROR(RMS)=		.1053	DRIFT DISTANCE=	.4295		
DIG CORR - X AXIS	MEAN	-2.168454E-01	RMS	7.706333E-02	BETA	-4.337640E-03
DIG CORR - Y AXIS	MEAN	8.260481E-02	RMS	4.333888E-02	BETA	1.622497E-03
RADIAL ERROR(RMS)=		.0884	DRIFT DISTANCE=	.4539		
EDGE - X AXIS	MEAN	-1.915880E-01	RMS	2.135969E-01	BETA	-5.091218E-03
EDGE - Y AXIS	MEAN	-5.412964E-02	RMS	1.739813E-01	BETA	1.411425E-03
RADIAL ERROR(RMS)=		.2755	DRIFT DISTANCE=	.5178		

TRACKING ERRORS

CENTROID - X AXIS

-.1221	-.1135	-.0923	-.1629	-.0133	.0566	.0739	.0526	.0988	-.1486
.0321	-.0140	-.1215	-.0823	-.0846	.1013	.2777	-.0039	.0293	-.0180
-.0333	-.1718	-.1286	-.2557	-.0253	-.1511	-.2973	-.1829	-.1834	-.0836
-.1903	-.2050	-.1613	-.2124	-.1038	-.2516	-.2101	-.2409	-.1504	-.4863
-.3676	-.3513	-.3330	-.3274	-.2940	-.3609	-.1391	-.2860	-.1899	-.3801
-.2980	-.2953	-.2484	-.4167	-.1752	-.3049	-.2960	-.3778	-.4800	-.2062
-.4854	-.4187	-.2591	-.3353	-.2182	-.3583	-.3087	-.3346	-.4102	-.3091
-.2761	-.3013	-.3677	-.3281	-.2942	-.3190	-.2490	-.2150	-.1944	-.3014
-.3124	-.2764	-.2966	-.4067	-.3674	-.3590	-.5001	-.3454	-.2839	-.4428
-.3533	-.3450	-.3851	-.3452	-.4095	.3763	-.4987	-.3135		

CENTROID - Y AXIS

-.0012	.0928	.0695	-.0047	.0368	-.0021	-.0050	-.0359	-.0535	.0059
.0095	.0167	.0434	.0006	-.0809	.0543	.0461	.0539	.0097	.0062
.0093	.1056	.0861	.0603	.0469	-.0000	.0321	.0055	.0821	.0429
-.0104	-.0431	-.0311	.0199	-.0162	-.0246	.0397	.0540	.0478	.0510
.0474	.0143	.1028	.1015	.0177	-.0135	-.0235	-.1206	-.0658	-.1289
-.0668	-.1412	-.0164	-.1162	-.0744	-.0080	.0387	-.0032	-.0547	.0093
.0325	.0679	.0182	.0393	.0005	.0018	.0375	.0576	.0645	.1100
.1072	.1131	.1026	-.0141	.0089	.0200	.0604	.0375	.1596	.1741
.2542	.2992	.2811	.2371	.0801	.0744	.0889	.0607	.0936	.0974
.0878	.0795	.1674	.0647	.0614	.1230	.1108	.1276		

DIG CORR - X AXIS

-.0019	-.0748	.0596	-.0613	.0191	.0319	.0935	.0684	.0719	-.0791
.0942	-.0353	.0586	.0194	.0566	.0781	.0938	-.0116	-.0033	-.0477
-.0326	-.1084	-.1611	-.1338	-.0579	-.1347	-.1120	-.1515	-.1508	-.1352
-.0972	-.1729	-.1025	-.1842	-.0886	-.1902	-.1819	-.2157	-.1957	-.3565
-.2691	-.3060	-.3595	-.3027	-.4262	-.3000	-.2890	-.3837	-.3495	-.3290
-.2944	-.3737	-.3015	-.3612	-.2354	-.3400	-.2940	-.3557	-.3684	-.2976
-.2806	-.3404	-.3072	-.3623	-.3015	-.3011	-.3306	-.3975	-.3535	-.3258
-.3088	-.3523	-.3215	-.2687	-.2803	-.2835	-.2411	-.2893	-.2917	-.3993
-.2490	-.3596	-.3800	-.4383	-.2761	-.3626	-.3436	-.3646	-.2832	-.3326
-.2785	-.3076	-.2892	-.3136	-.2942	-.3391	-.2816	-.3465		

DIG CORR - Y AXIS

-.0188	-.0137	-.0110	.0177	.0191	.0470	.0487	.0367	.0370	.0447
.0695	.0813	.0655	.0341	.0397	.0592	.0899	.0904	.0607	.0457
.0443	.0696	.1307	.0932	.1107	.0813	.0408	.0405	.0333	.0138
.0194	.0250	.0384	.0205	.0328	.0406	.0406	.0802	.0697	.0824
.0399	.0309	.0394	.0470	.0151	.0139	-.0296	-.0334	-.0111	-.0091
.0039	-.0075	.0213	.0231	.0035	.0274	.0201	.0367	.0730	.0875
.1002	.1274	.1314	.1382	.1552	.1141	.0993	.1110	.1381	.1452
.1459	.1696	.1193	.1048	.1099	.1319	.1075	.1032	.1466	.1805
.1602	.2116	.2016	.1847	.1869	.1515	.1426	.1331	.1453	.1805
.1965	.1839	.2079	.1565	.1487	.1853	.1765	.2119		

TRACKING ERRORS (Continued)

EDGE - X AXIS

.0681	-.0691	-.2498	-.4562	.1661	.6088	.1580	.0909	.0406	-.4846
.0186	-.0828	.0261	-.2820	-.7222	.2676	1.3034	-.0720	.3869	.0109
.3918	-.1220	.0151	-.1396	.1965	-.0639	-.2215	-.0770	-.2101	-.1092
-.2448	-.0496	-.0686	.0513	-.3113	-.2498	-.2405	.0676	-.1185	-.7329
-.3423	-.3270	-.3166	-.3525	-.3167	-.2645	1.0458	-.3247	.4222	-.3061
-.1376	-.4260	.0308	-.5305	-.3234	.0585	-.4167	-.8179	-.5685	.4356
-.6047	-.4321	-.1995	-.4936	-.2929	.2988	-.3030	-.6106	-.4365	-.1064
-.4792	-.4589	-.5939	-.2987	-.0762	-.3111	-.4656	-.6384	-.5511	-.6411
-.3510	-.3086	-.0991	-.4241	-.4294	-.1968	-.3904	-.6119	.2995	-.6130
-.1484	-.4617	-.1303	-.3942	-.4065	-.4589	-.2805	-.2661		

EDGE - Y AXIS

.3786	.4942	.3774	-.1935	-.1478	-.2227	-.1609	-.2143	-.1793	-.1504
-.1051	-.0620	.1284	-.2241	-.3147	-.1959	-.0088	-.0113	-.3447	-.1912
-.0307	.0273	-.0395	-.1578	.0511	-.0361	.0006	-.0419	-.0340	-.1285
-.1622	-.2914	-.1100	-.1503	-.1529	-.0420	-.0964	-.1022	-.1172	-.1007
.0076	-.2150	.5268	.1525	.1609	-.2030	-.1981	-.2802	-.2084	-.2088
-.1074	-.1973	-.2433	-.1960	-.0905	-.1654	-.1335	-.2162	-.1369	-.0719
.0006	-.1563	.0339	-.0751	-.1004	-.0983	.0252	-.1857	.0111	-.0854
-.0951	-.1804	-.1779	-.1617	-.1632	-.1216	-.0394	-.1070	.0625	.1154
.5004	.5695	.7811	.4157	.1961	.0734	.0111	-.1698	.0790	-.0109
-.0928	-.1158	-.0590	-.0187	-.0579	-.1443	.0230	-.2035		

FILTERED TRACKER DATA

CENTROID - X AXIS

0.0000	0.0000	-.0865	-.1505	-.1146	-.0143	.0742	.0931	.0869	-.0069
-.0497	-.0409	-.0502	-.0813	-.0992	-.0217	.1459	.1772	.0926	-.0109
-.0506	-.1005	-.1392	-.1985	-.1587	-.1174	-.1688	-.2267	-.2271	-.1530
-.1264	-.1600	-.1895	-.2021	-.1658	-.1750	-.2037	-.2365	-.2121	-.2950
-.3858	-.4125	-.3665	-.3240	-.3005	-.3177	-.2643	-.2320	-.2073	-.2715
-.3232	-.3308	-.2866	-.3116	-.2894	-.2729	-.2713	-.3237	-.4130	-.3784
-.3720	-.3968	-.3718	-.3232	-.2608	-.2755	-.3091	-.3372	-.3697	-.3642
-.3192	-.2830	-.3076	-.3404	-.3341	-.3136	-.2807	-.2407	-.2031	-.2273
-.2850	-.3116	-.3046	-.3349	-.3730	-.3838	-.4222	-.4194	-.3566	-.3455
-.3643	-.3714	-.3686	-.3601	-.3754	-.3865	-.4335	-.4142		

CENTROID - Y AXIS

0.0000	0.0000	.0537	.0598	.0355	.0074	-.0053	-.0207	-.0406	-.0326
-.0055	.0182	.0341	.0268	-.0222	-.0233	.0173	.0588	.0507	.0193
-.0003	.0374	.0847	.0947	.0685	.0259	.0094	.0076	.0385	.0586
.0378	-.0136	-.0458	-.0268	-.0032	-.0039	.0047	.0325	.0551	.0588
.0518	.0337	.0504	.0857	.0787	.0265	-.0233	-.0759	-.0952	-.1097
-.0974	-.1056	-.0790	-.0750	-.0769	-.0562	-.0014	.0272	-.0018	-.0230
-.0040	.0426	.0549	.0633	.0431	.0147	.0080	.0325	.0611	.0899
.1084	.1163	.1114	.0594	.0073	-.0080	.0238	.0499	.0986	.1529
.2172	.2748	.3008	.2791	.1836	.0870	.0505	.0569	.0789	.0951
.0982	.0890	.1129	.1136	.0874	.0812	.0999	.1233		

DIG CORR - X AXIS

0.0000	0.0000	.0006	-.0166	-.0107	.0090	.0562	.0842	.0856	.0165
.0030	-.0015	.0241	.0323	.0445	.0613	.0837	.0569	.0101	-.0349
-.0483	-.0711	-.1186	-.1514	-.1229	-.1003	-.1011	-.1288	-.1508	-.1523
-.1265	-.1283	-.1275	-.1483	-.1363	-.1459	-.1676	-.2008	-.2117	-.2667
-.3022	-.3138	-.3264	-.3283	-.3635	-.3606	-.3240	-.3208	-.3445	-.3538
-.3262	-.3262	-.3260	-.3392	-.3048	-.2946	-.2956	-.3250	-.3560	-.3477
-.3075	-.2972	-.3078	-.3368	-.3362	-.3162	-.3084	-.3453	-.3741	-.3627
-.3260	-.3187	-.3257	-.3089	-.2823	-.2712	-.2609	-.2658	-.2807	-.3356
-.3332	-.3275	-.3436	-.3983	-.3790	-.3447	-.3279	-.3460	-.3332	-.3186
-.2973	-.2937	-.2927	-.3015	-.3034	-.3165	-.3109	-.3182		

DIG CORR - Y AXIS

0.0000	0.0000	-.0110	-.0041	.0125	.0340	.0485	.0487	.0408	.0379
.0509	.0715	.0787	.0606	.0394	.0392	.0645	.0896	.0873	.0632
.0424	.0545	.0965	.1184	.1172	.0976	.0664	.0406	.0291	.0223
.0180	.0190	.0286	.0311	.0306	.0334	.0392	.0575	.0725	.0817
.0672	.0426	.0292	.0348	.0334	.0221	-.0049	-.0294	-.0318	-.0181
-.0014	.0023	.0081	.0174	.0174	.0180	.0196	.0280	.0494	.0763
.0973	.1153	.1289	.1375	.1465	.1385	.1160	.1014	.1130	.1363
.1507	.1605	.1486	.1223	.1031	.1099	.1177	.1139	.1211	.1512
.1727	.1923	.2034	.2007	.1899	.1699	.1498	.1348	.1344	.1549
.1838	.1968	.2016	.1852	.1606	.1577	.1707	.1947		

FILTERED TRACKER DATA (Continued)

EDGE - X AXIS

0.0000	0.0000	-.1060	-.3126	-.2319	.2013	.4451	.3312	.0857	-.2278
-.2752	-.1618	-.0021	-.0590	-.3852	-.3290	.4327	.7274	.5457	.1429
.0994	.0729	.0312	-.0753	-.0128	.0316	-.0543	-.1424	-.1904	-.1647
-.1771	-.1424	-.0902	-.0062	-.0869	-.2222	-.2959	-.1585	-.0425	-.2740
-.4901	-.4925	-.3554	-.2926	-.3018	-.3024	.2227	.3604	.3294	.0073
-.1880	-.3474	-.2486	-.2672	-.3287	-.2291	-.1967	-.4510	-.6843	-.3196
-.1206	-.2337	-.3712	-.4229	-.3786	-.0960	.0071	-.2432	-.5181	-.4426
-.3316	-.3534	-.5022	-.4950	-.2890	-.1671	-.2694	-.5088	-.6374	-.6569
-.5263	-.3642	-.1899	-.2116	-.3483	-.3712	-.3436	-.4293	-.2270	-.2083
-.2237	-.3548	-.3142	-.2987	-.3382	-.4260	-.4067	-.3170		

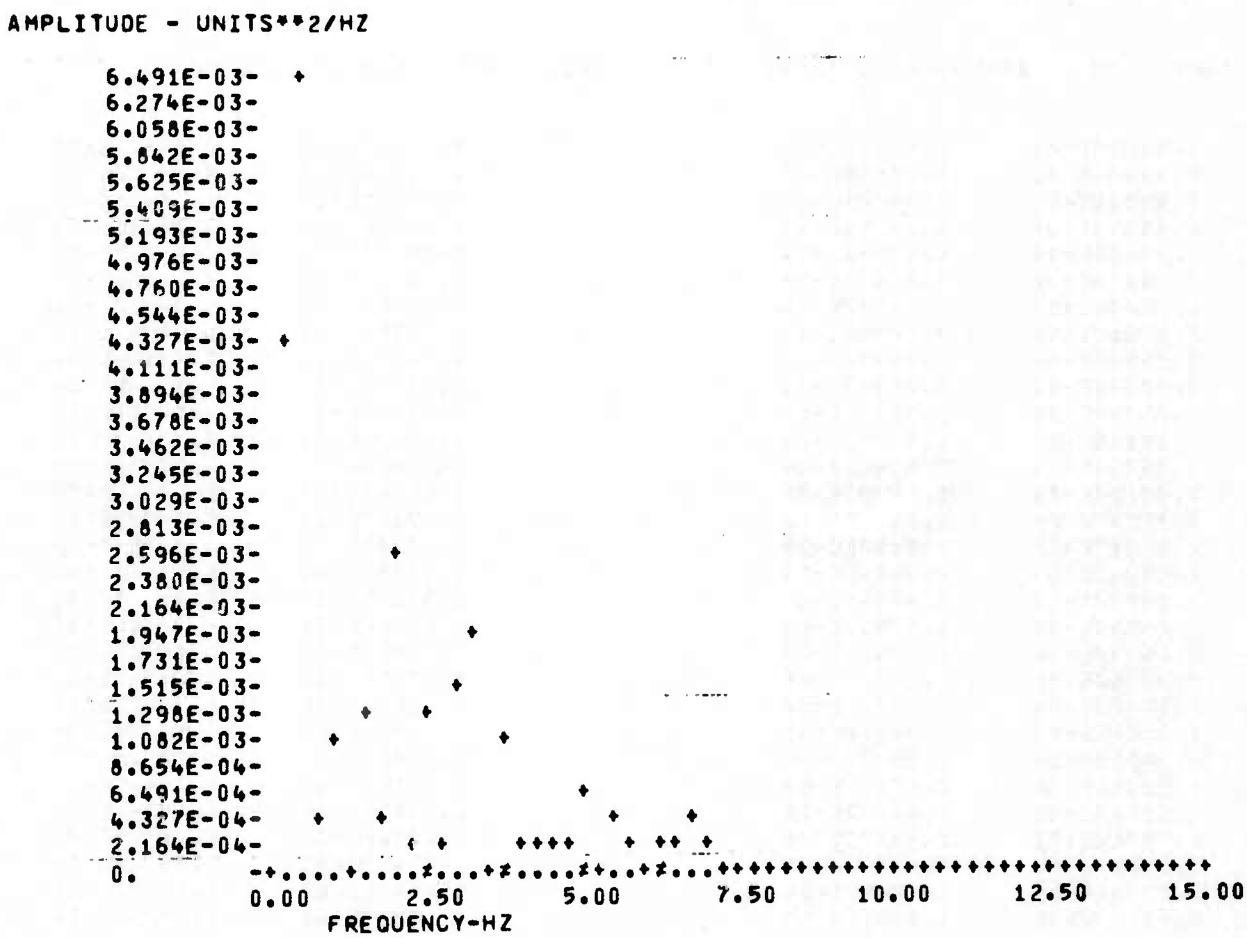
EDGE - Y AXIS

0.0000	0.0000	.3449	.2863	-.0273	-.2674	-.2769	-.2141	-.1719	-.1578
-.1338	-.0922	.0133	-.0193	-.1820	-.2872	-.1933	-.0382	-.0912	-.2101
-.1956	-.0563	.0253	-.0360	-.0596	-.0404	-.0036	-.0094	-.0289	-.0770
-.1347	-.2213	-.2198	-.1709	-.1326	-.0936	-.0750	-.0806	-.1052	-.1148
-.0674	-.0908	.1157	.2717	.2841	.0464	-.1838	-.3052	-.2860	-.2263
-.1529	-.1400	-.1873	-.2244	-.1801	-.1356	-.1219	-.1632	-.1782	-.1360
-.0508	-.0505	-.0417	-.0461	-.0652	-.0961	-.0613	-.0772	-.0656	-.0643
-.0708	-.1242	-.1750	-.1886	-.1740	-.1440	-.0901	-.0681	-.0179	.0606
.2718	.5012	.7055	.6657	.4159	.1361	-.0156	-.1049	-.0667	-.0047
-.0072	-.0753	-.1064	-.0707	-.0368	-.0701	-.0657	-.1024		

SPECTRAL DENSITY CENTROID - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	4.38936E-03	7.75000E+00	9.28530E-05
5.00000E-01	6.49080E-03	8.00000E+00	1.28658E-05
7.50000E-01	4.12128E-04	8.25000E+00	8.53763E-05
1.00000E+00	1.01372E-03	8.50000E+00	1.82631E-05
1.25000E+00	9.67698E-05	8.75000E+00	4.28427E-06
1.50000E+00	1.25091E-03	9.00000E+00	1.96320E-05
1.75000E+00	4.62078E-04	9.25000E+00	3.05904E-06
2.00000E+00	2.53211E-03	9.50000E+00	9.31013E-06
2.25000E+00	1.89996E-04	9.75000E+00	1.20618E-05
2.50000F+00	1.35952E-03	1.00000E+01	1.43539E-05
2.75000E+00	1.42220E-04	1.02500E+01	1.41375E-06
3.00000E+00	1.55686E-03	1.05000E+01	6.52241E-06
3.25000E+00	2.00248E-03	1.07500E+01	2.95347E-06
3.50000E+00	5.65601E-05	1.10000E+01	1.36083E-05
3.75000E+00	1.02942E-03	1.12500E+01	1.82928E-05
4.00000E+00	1.91316E-04	1.15000E+01	1.34823E-06
4.25000E+00	1.33842E-04	1.17500E+01	1.75724E-05
4.50000E+00	1.59297E-04	1.20000E+01	1.79473E-06
4.75000E+00	1.50182E-04	1.22500E+01	1.51079E-06
5.00000E+00	6.57852E-04	1.25000E+01	5.76677E-06
5.25000E+00	1.03324E-04	1.27500E+01	2.17722E-05
5.50000E+00	3.25312E-04	1.30000E+01	7.85771E-06
5.75000E+00	1.51709E-04	1.32500E+01	5.90235E-06
6.00000E+00	4.63176E-05	1.35000E+01	1.49782E-06
6.25000E+00	1.75788E-04	1.37500E+01	1.96094E-06
6.50000E+00	2.63689E-04	1.40000E+01	8.58714E-06
6.75000E+00	4.08721E-04	1.42500E+01	5.86310E-06
7.00000E+00	2.94017E-04	1.45000E+01	2.95373E-07
7.25000E+00	7.95243E-05	1.47500E+01	2.32108E-05
7.50000E+00	3.05980E-05	1.50000E+01	1.66863E-05

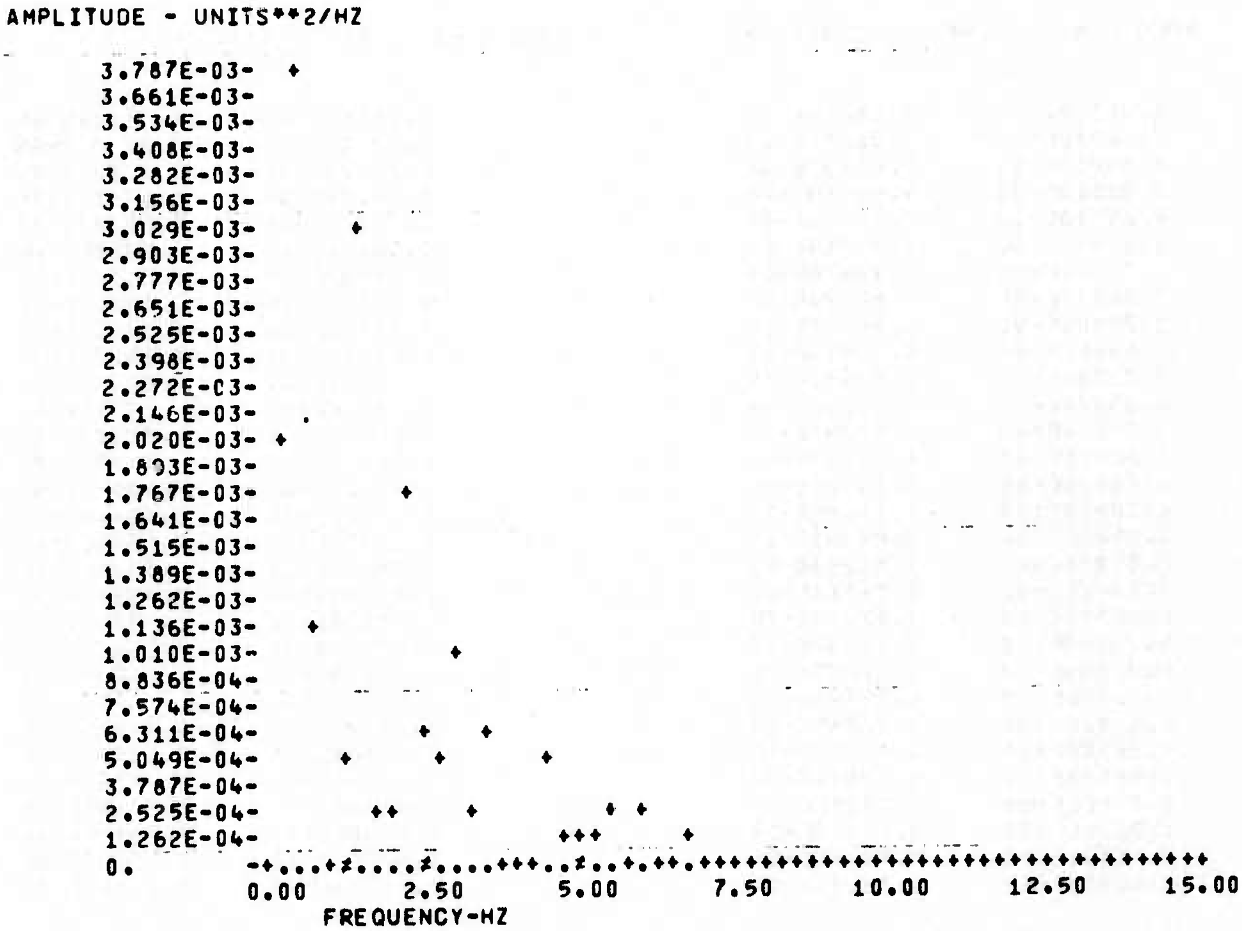
SPECTRAL DENSITY CENTROID - X AXIS



SPECTRAL DENSITY CENTROID - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.97012E-03	7.75000E+00	2.27570E-05
5.00000E-01	3.78685E-03	8.00000E+00	3.19426E-06
7.50000E-01	1.08296E-03	8.25000E+00	1.47498E-05
1.00000E+00	4.68020E-06	8.50000E+00	3.36065E-06
1.25000E+00	4.69540E-04	8.75000E+00	1.44552E-06
1.50000E+00	3.07937E-03	9.00000E+00	2.74302E-05
1.75000E+00	2.04927E-04	9.25000E+00	1.38672E-06
2.00000E+00	3.12555E-04	9.50000E+00	8.96753E-07
2.25000E+00	1.74923E-03	9.75000E+00	2.98648E-06
2.50000E+00	5.75993E-04	1.00000E+01	1.53281E-06
2.75000E+00	5.57294E-04	1.02500E+01	1.57828E-06
3.00000E+00	9.83982E-04	1.05000E+01	2.93213E-07
3.25000E+00	2.92662E-04	1.07500E+01	1.57962E-06
3.50000E+00	6.57993E-04	1.10000E+01	1.47471E-06
3.75000E+00	1.59612E-05	1.12500E+01	7.26090E-07
4.00000E+00	2.09870E-05	1.15000E+01	1.26993E-06
4.25000E+00	1.65716E-05	1.17500E+01	1.81477E-06
4.50000E+00	5.45950E-04	1.20000E+01	6.95119E-07
4.75000E+00	1.07592E-04	1.22500E+01	7.35221E-07
5.00000E+00	8.15463E-05	1.25000E+01	6.80514E-07
5.25000E+00	7.15358E-05	1.27500E+01	3.36946E-06
5.50000E+00	2.75715E-04	1.30000E+01	1.32226E-06
5.75000E+00	2.36018E-05	1.32500E+01	2.56339E-06
6.00000E+00	1.99932E-04	1.35000E+01	1.33524E-06
6.25000E+00	1.57057E-05	1.37500E+01	5.89036E-06
6.50000E+00	1.06730E-05	1.40000E+01	1.27295E-06
6.75000E+00	7.93873E-05	1.42500E+01	5.40979E-06
7.00000E+00	1.43722E-06	1.45000E+01	7.99229E-07
7.25000E+00	8.29647E-06	1.47500E+01	3.74692E-07
7.50000E+00	1.00611E-05	1.50000E+01	1.53392E-06

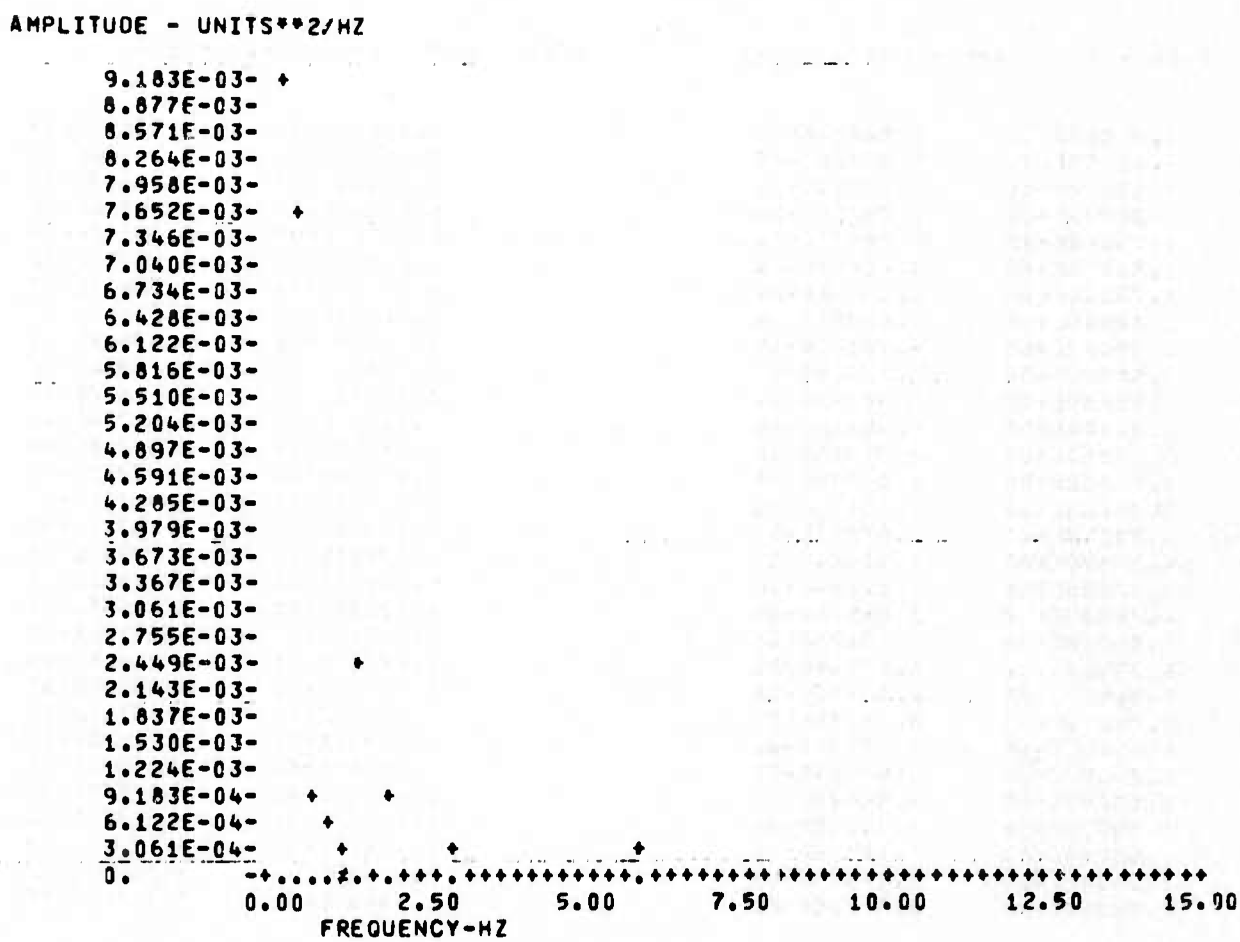
SPECTRAL DENSITY CENTROID - Y AXIS



SPECTRAL DENSITY DIG CORR - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	9.18274E-03
5.00000E-01	7.60651E-03
7.50000E-01	7.65493E-04
1.00000E+00	4.96279E-04
1.25000E+00	2.28311E-04
1.50000E+00	2.39269E-03
1.75000E+00	5.88420E-05
2.00000E+00	7.90493E-04
2.25000E+00	4.40653E-05
2.50000E+00	8.30919E-05
2.75000E+00	7.55480E-05
3.00000E+00	4.35006E-04
3.25000E+00	1.10397E-04
3.50000E+00	8.20162E-05
3.75000E+00	1.39302E-04
4.00000E+00	1.86186E-05
4.25000E+00	9.88481E-06
4.50000E+00	3.06283E-05
4.75000E+00	2.78718E-05
5.00000E+00	9.97410E-05
5.25000E+00	1.65397E-05
5.50000E+00	6.74055E-06
5.75000E+00	4.76690E-05
6.00000E+00	3.15555E-04
6.25000E+00	3.15357E-05
6.50000E+00	1.52514E-05
6.75000E+00	1.05251E-04
7.00000E+00	3.74323E-05
7.25000E+00	9.89050E-07
7.50000E+00	1.73321E-05
7.75000E+00	7.37810E-05
8.00000E+00	2.22494E-05
8.25000E+00	1.70781E-05
8.50000E+00	8.62121E-06
8.75000E+00	9.07738E-07
9.00000E+00	5.58638E-06
9.25000E+00	1.21782E-06
9.50000E+00	6.30260E-06
9.75000E+00	8.88108E-06
1.00000E+01	3.39323E-06
1.02500E+01	2.92541E-06
1.05000E+01	1.22855E-06
1.07500E+01	1.30323E-05
1.10000E+01	3.24920E-06
1.12500E+01	6.42077E-06
1.15000E+01	2.62448E-06
1.17500E+01	3.16662E-06
1.20000E+01	1.04362E-06
1.22500E+01	2.41461E-06
1.25000E+01	1.69368E-06
1.27500E+01	7.26815E-06
1.30000E+01	1.97735E-06
1.32500E+01	1.75553E-06
1.35000E+01	3.95729E-06
1.37500E+01	9.08181E-06
1.40000E+01	3.19288E-06
1.42500E+01	4.57659E-06
1.45000E+01	7.56354E-06
1.47500E+01	3.67969E-06
1.50000E+01	2.53213E-05

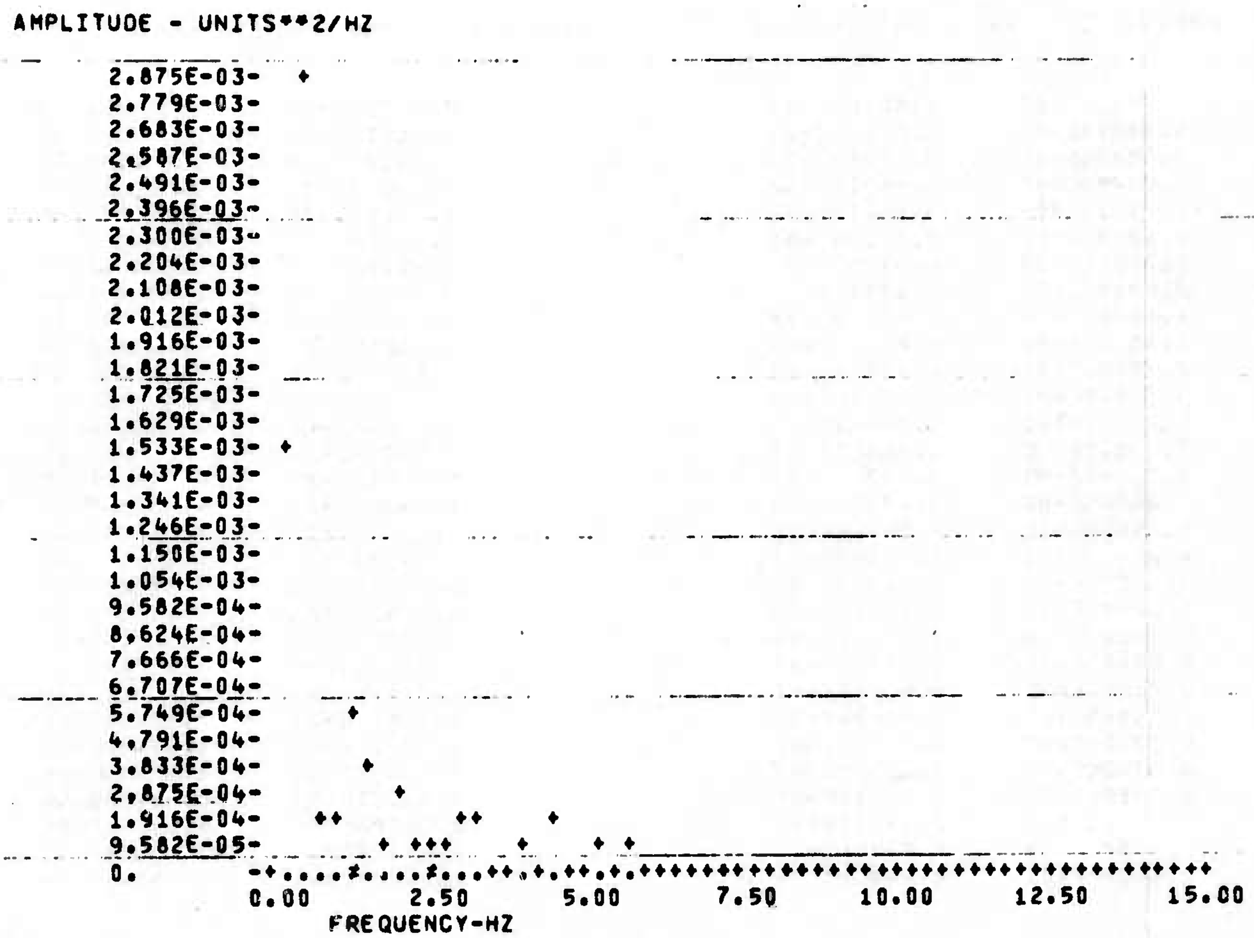
SPECTRAL DENSITY DIG CORR - X AXIS



SPECTRAL DENSITY DIG CORR - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.54720E-03	7.75000E+00	7.50479E-07
5.00000E-01	2.87464E-03	8.00000E+00	3.21128E-07
7.50000E-01	2.27514E-04	8.25000E+00	2.56503E-06
1.00000E+00	1.56717E-04	8.50000E+00	5.89576E-06
1.25000E+00	6.06593E-04	8.75000E+00	2.68131E-06
1.50000E+00	3.40687E-04	9.00000E+00	1.58213E-06
1.75000E+00	1.15766E-04	9.25000E+00	1.76625E-07
2.00000E+00	2.62357E-04	9.50000E+00	4.59149E-07
2.25000E+00	9.72105E-05	9.75000E+00	8.93561E-07
2.50000E+00	7.65430E-05	1.00000E+01	9.78380E-07
2.75000E+00	1.38241E-04	1.02500E+01	2.83822E-07
3.00000E+00	1.96266E-04	1.05000E+01	2.56274E-07
3.25000E+00	2.26716E-04	1.07500E+01	3.38748E-08
3.50000E+00	1.00236E-05	1.10000E+01	1.83272E-07
3.75000E+00	5.10896E-06	1.12500E+01	3.94121E-07
4.00000E+00	5.67673E-05	1.15000E+01	1.79712E-06
4.25000E+00	7.13264E-06	1.17500E+01	4.71481E-07
4.50000E+00	2.07144E-04	1.20000E+01	6.07392E-07
4.75000E+00	2.04514E-05	1.22500E+01	2.98657E-07
5.00000E+00	3.13125E-05	1.25000E+01	5.83891E-07
5.25000E+00	6.09749E-05	1.27500E+01	1.01424E-06
5.50000E+00	4.33502E-05	1.30000E+01	3.69187E-07
5.75000E+00	8.47179E-05	1.32500E+01	1.27564E-07
6.00000E+00	1.37732E-06	1.35000E+01	1.32088E-06
6.25000E+00	5.04743E-07	1.37500E+01	5.88939E-07
6.50000E+00	2.96401E-06	1.40000E+01	8.87029E-07
6.75000E+00	3.35168E-06	1.42500E+01	1.45788E-08
7.00000E+00	1.17396E-06	1.45000E+01	3.15947E-07
7.25000E+00	3.17579E-06	1.47500E+01	3.76692E-07
7.50000E+00	3.98205E-06	1.50000E+01	9.05182E-07

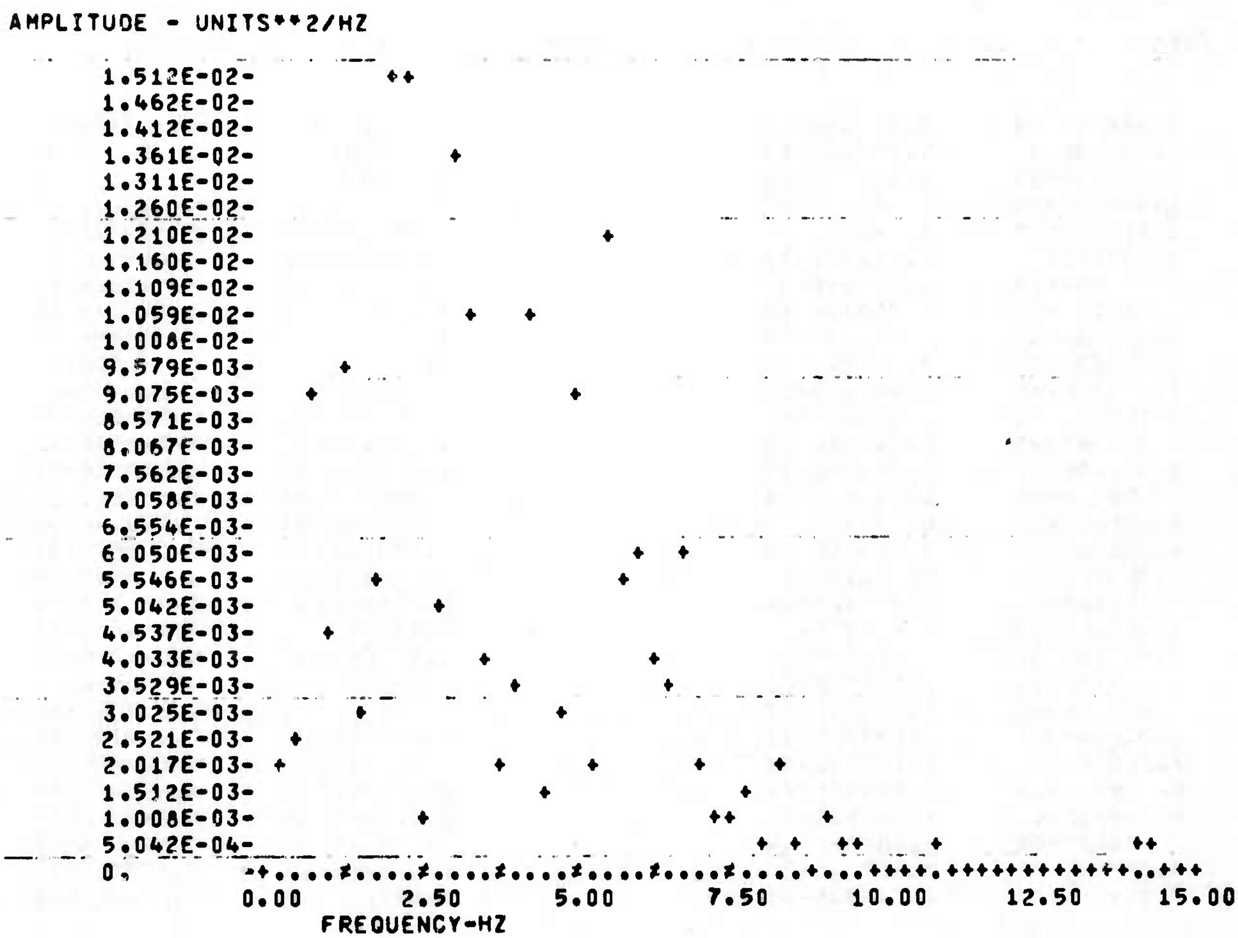
SPECTRAL DENSITY DIG CORR - Y AXIS



SPECTRAL DENSITY EDGE - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.96266E-03	7.75000E+00	1.33087E-03
5.00000E-01	2.63157E-03	8.00000E+00	2.96031E-04
7.50000E-01	9.17385E-03	8.25000E+00	2.05035E-03
1.00000E+00	4.66236E-03	8.50000E+00	2.98218E-04
1.25000E+00	9.49434E-03	8.75000E+00	8.65027E-05
1.50000E+00	2.88198E-03	9.00000E+00	7.94493E-04
1.75000E+00	5.38230E-03	9.25000E+00	3.27779E-04
2.00000E+00	1.49989E-02	9.50000E+00	2.53189E-04
2.25000E+00	1.51249E-02	9.75000E+00	2.02552E-04
2.50000E+00	8.68604E-04	1.00000E+01	2.26602E-04
2.75000E+00	4.88084E-03	1.02500E+01	5.67779E-06
3.00000E+00	1.35196E-02	1.05000E+01	8.44918E-05
3.25000E+00	1.04642E-02	1.07500E+01	3.02999E-04
3.50000E+00	3.92882E-03	1.10000E+01	7.53468E-05
3.75000E+00	2.15778E-03	1.12500E+01	9.30908E-05
4.00000E+00	3.42338E-03	1.15000E+01	4.11364E-05
4.25000E+00	1.04668E-02	1.17500E+01	4.86990E-05
4.50000E+00	1.43096E-03	1.20000E+01	2.37261E-05
4.75000E+00	2.94393E-03	1.22500E+01	7.18279E-06
5.00000E+00	9.18675E-03	1.25000E+01	3.11130E-05
5.25000E+00	2.22216E-03	1.27500E+01	1.05819E-04
5.50000E+00	1.20747E-02	1.30000E+01	9.21748E-05
5.75000E+00	5.45803E-03	1.32500E+01	1.49614E-05
6.00000E+00	5.81054E-03	1.35000E+01	7.37894E-05
6.25000E+00	4.21027E-03	1.37500E+01	1.66745E-04
6.50000E+00	3.46939E-03	1.40000E+01	2.98992E-04
6.75000E+00	6.02138E-03	1.42500E+01	3.42866E-04
7.00000E+00	2.16108E-03	1.45000E+01	5.14564E-05
7.25000E+00	1.03307E-03	1.47500E+01	3.45909E-05
7.50000E+00	8.44457E-04	1.50000E+01	2.24646E-04

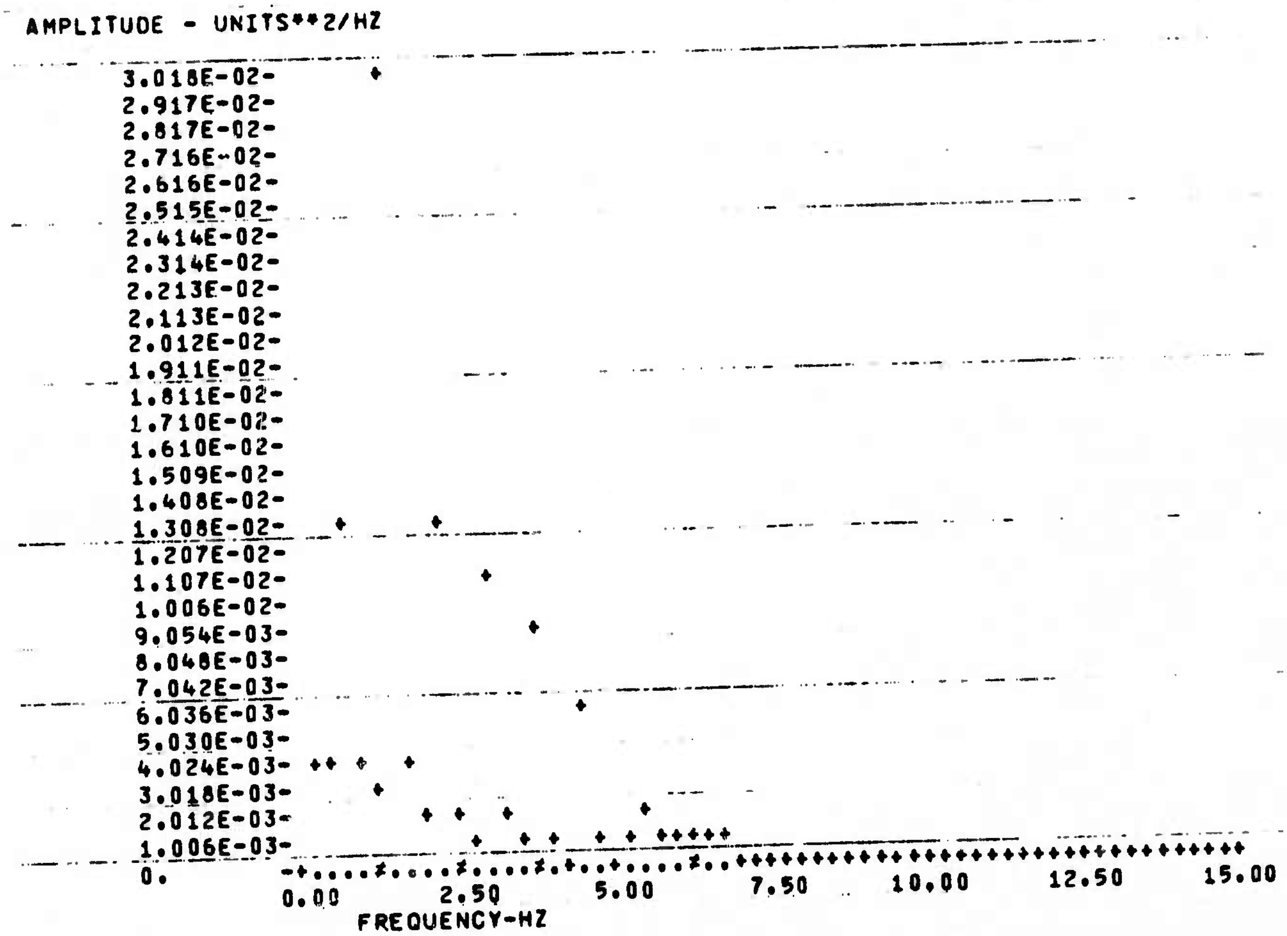
SPECTRAL DENSITY EDGE - X AXIS



SPECTRAL DENSITY EDGE - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	3.77348E-03	7.75000E+00	1.74317E-04
5.00000E-01	4.25041E-03	8.00000E+00	3.26289E-04
7.50000E-01	1.27618E-02	8.25000E+00	1.80862E-04
1.00000E+00	3.89911E-03	8.50000E+00	4.01098E-05
1.25000E+00	2.66190E-03	8.75000E+00	6.71175E-05
1.50000E+00	3.01801E-02	9.00000E+00	1.65594E-04
1.75000E+00	3.68559E-03	9.25000E+00	7.30192E-06
2.00000E+00	1.71875E-03	9.50000E+00	2.90895E-05
2.25000E+00	1.32619E-02	9.75000E+00	7.86629E-05
2.50000E+00	2.18924E-03	1.00000E+01	5.10298E-05
2.75000E+00	8.50523E-04	1.02500E+01	1.10075E-05
3.00000E+00	1.12711E-02	1.05000E+01	3.52131E-05
3.25000E+00	1.54821E-03	1.07500E+01	7.34193E-06
3.50000E+00	1.24945E-03	1.10000E+01	2.53251E-05
3.75000E+00	9.54721E-03	1.12500E+01	5.05705E-05
4.00000E+00	6.17751E-04	1.15000E+01	1.77994E-05
4.25000E+00	1.18426E-04	1.17500E+01	3.03564E-05
4.50000E+00	5.67257E-03	1.20000E+01	3.64550E-05
4.75000E+00	7.33602E-04	1.22500E+01	6.98037E-05
5.00000E+00	2.60012E-04	1.25000E+01	3.05982E-05
5.25000E+00	8.99726E-04	1.27500E+01	6.81433E-05
5.50000E+00	2.12221E-03	1.30000E+01	3.97258E-06
5.75000E+00	1.22993E-03	1.32500E+01	1.65869E-06
6.00000E+00	1.08507E-03	1.35000E+01	7.38632E-05
6.25000E+00	1.09079E-03	1.37500E+01	3.68595E-05
6.50000E+00	9.07659E-04	1.40000E+01	3.55111E-05
6.75000E+00	5.45590E-04	1.42500E+01	4.04367E-05
7.00000E+00	3.49762E-04	1.45000E+01	8.42615E-06
7.25000E+00	2.02723E-05	1.47500E+01	2.32384E-06
7.50000E+00	7.70033E-05	1.50000E+01	3.05470E-04

SPECTRAL DENSITY EDGE - Y AXIS



CDC 6600 CSP Printout VI

Reference Program: Processing of IR data for stationary target in wide field of view

Tracking Program: Run no. 90 using above referenced data

```
DIGITAL CORRELATION TRACKER - REFERENCING PROGRAM

PROCESS 89 PICTURES
SEARCH WINDOW IS 16 X  16
STARTING TARGET COORDINATES ARE (43,41)
TAPE OUTPUT OPTION IS 1

CONTRAST .......NEG
```

COORDINATE ERROR ANALYSIS

STARTING COORDINATES * X= 41.00
Y= 43.00

****

NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR
1	0.00	0.00	2	2.44	.13	3	.06	-.06
4	2.50	.06	5	-.06	-.06	6	3.25	.13
7	.56	.25	8	3.31	.13	9	.06	.31
10	2.44	.38	11	-.19	.19	12	2.31	.06
13	-.25	-.19	14	2.19	-.06	15	-.13	-.19
16	2.50	-.06	17	-.13	.13	18	2.56	0.00
19	-.19	-.19	20	2.31	-.25	21	-.13	-.06
22	2.38	.06	23	-.19	-.06	24	2.44	-.25
25	-.19	-.13	26	3.19	.13	27	.44	0.00
28	3.06	.06	29	-.31	-.06	30	2.31	-.19
31	-.06	-.06	32	2.44	-.19	33	-.13	-.06
34	2.44	.13	35	-.19	0.00	36	2.19	-.13
37	-.06	-.25	38	2.63	-.06	39	-.69	-.19
40	2.81	-.31	41	-.69	-.19	42	1.94	-.13
43	-.56	-.06	44	2.13	0.00	45	-.50	.19
46	2.75	.25	47	-.63	.06	48	2.69	-.06
49	-.06	.06	50	2.56	.25	51	-.13	.44
52	2.25	.31	53	-.25	.13	54	2.25	.25
55	-.31	.38	56	2.06	.44	57	-.38	.56
58	2.94	.75	59	.19	1.00	60	2.94	.88
61	.31	.81	62	3.06	.75	63	-.19	.56
64	2.31	.44	65	-.19	.31	66	2.25	.44
67	-.31	.63	68	3.06	.81	69	.38	.69
70	3.06	.81	71	-.44	.69	72	3.25	.56
73	0.00	.69	74	2.56	.88	75	.06	.94
76	2.44	.88	77	0.00	.75	78	2.44	.69
79	.13	.63	80	2.75	.75	81	.06	.56
82	3.31	.38	83	-.06	.56	84	2.50	.50
85	-.06	.38	86	2.44	.25	87	-.13	.44
88	2.38	.56	89	0.00	.44			

SIGNAL/NOISE DETERMINATION

S LE	SIGNAL LEVEL	NOISE LEVEL	S/N
1	11.65	3.59	3.24
2	11.87	3.34	3.55
3	11.83	3.57	3.31
4	11.79	3.55	3.32
5	11.70	3.62	3.23
6	11.39	4.74	2.40
7	11.51	4.36	2.64
8	11.74	3.26	3.60

RESULTANT SIGNAL/NOISE = 3.163

```
TRACKING RUN NO. 90

     X DIMENSION = 16          Y DIMENSION = 16
     X CENTER = 32             Y CENTER = 32
     PRINTOUT EVERY 99 FRAMES
     INPUT FROM UNIT  1
       0 FRAMES SKIPPED,  89 FRAMES PROCESSED
     FREQUENCY =  30.00
     5 INPUT BITS USED
     ICOLPS = 0       IOFF = 0
     SCALOF =    4.00       SFACX =    5.00       SFACY =    5.00
     AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
     LINEAR PROCESSING FOR CORRELATION TRACKER
     CORRELATION METHOD - SUM OF ABS VALUES
     UPDATE AT 10 FRAMES(SKIP)
     LINEAR PROCESSING ABOVE THRESHOLD OF - 20 FOR CENTROID TRACKER

CENTROID - X AXIS  GAIN =     .98807

CENTROID - Y AXIS  GAIN =    1.02494

DIG CORR - X AXIS  GAIN =    1.00000

DIG CORR - Y AXIS  GAIN =    1.00000

EDGE - X AXIS      GAIN =     .76715

EDGE - Y AXIS      GAIN =     .86057
```

SAMPLE NO. 88 RUN NO. 90

INPUT PICTURE (X OFFSET = -1, Y OFFSET = 3)

INPUT DATA DIVIDED PY 2

6	6	8	8	8	6	6	6	5	6	8	8	7	6	7	6	7	5	6	6	7	8	6	7	5	5	7	6	7	6	6	6
4	6	4	6	4	5	6	4	5	6	4	4	5	4	4	6	4	5	5	6	6	6	5	4	5	5	6	6	5	5	6	5
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6	2	5	6	4	4	5	5	4	4	5	4	6	4	5	5	5	4	4	4	5	4	2	5	4	4	4	5	4	4	5	6
6	4	6	5	7	6	5	5	6	6	5	7	6	5	5	5	5	4	6	4	6	5	4	4	5	4	6	4	5	5	5	6
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4	7	5	6	5	5	5	6	6	6	5	5	6	6	5	6	6	6	6	5	5	4	6	5	6	6	5	5	6	6	6	6
6	7	6	5	6	7	6	4	6	6	6	8	5	5	5	7	4	7	7	6	7	7	6	4	6	5	6	5	7	5	8	6
6	6	6	5	7	6	6	7	5	5	6	5	7	4	6	6	5	4	5	5	6	5	4	6	5	6	6	5	6	6	5	6
6	5	7	6	8	6	6	7	7	6	6	8	6	6	5	7	7	6	6	6	4	6	7	6	4	6	6	7	6	6	6	6
7	6	6	6	7	7	5	5	5	6	4	7	6	6	6	6	6	6	6	6	6	8	6	6	4	7	6	5	6	4	6	6

SAMPLE NO. 88 RUN NO. 90

VIDEO GRADIENTS

INPUT DATA DIVIDED BY 2

1	3	5	4	3	.	1	1	2	3	5	4	3	3	2	2	2	1	1	.	1	3	3	2	.	2	1	2	2	1	1	.
3	3	3	1	1	2	2	1	2	2	.	1	.	.	1	2	2	.	1	.	3	2	1	1	1	1	2	1	1	2	1	.
2	2	2	1	2	1	1	2	1	1	1	1	.	.	.	1	2	.	1	3	1	2	2	2	2	1	.	.	1	2	2	.
.	.	.	2	2	2	1	2	2	1	1	1	2	2	.	.	1	1	2	2	3	.	2	2	2	1	.	.	1	2	2	.
3	2	2	2	2	2	.	.	1	1	1	1	.	2	.	.	.	2	1	1	2	3	1	.	.	1	1	.	1	2	1	.
5	4	.	.	3	1	.	1	2	1	2	3	2	1	.	.	1	1	1	2	1	3	2	.	1	2	1	.	1	1	1	.
3	3	1	2	1	1	1	1	1	.	1	4	2	1	1	.	.	2	3	3	2	1	.	.	.	1	1	.	1	.	1	.
2	1	.	.	2	2	.	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	2	1	2	3	2	.	1	2	1	.
.	1	1	1	2	1	.	2	3	2	1	1	2	.	1	1	1	1	3	2	4	2	1	1	2	2	.	1	2	.	1	.
1	2	1	1	1	1	1	2	2	.	1	1	.	1	.	1	4	1	1	.	3	2	2	2	1	.	1	4	3	3	2	.
.	1	2	2	1	2	1	1	1	2	1	1	1	1	1	2	4	3	1	.	2	2	.	2	1	.	.	2	2	1	2	.
1	.	1	1	3	4	3	2	3	2	1	1	2	2	1	3	3	1	1	2	2	2	2	.	2	2	2	2	2	1	2	.
.	2	.	.	.	4	3	1	3	1	1	1	1	1	1	1	1	2	1	.	1	.	2	.	1	2	2	1	2	.	1	.
.	3	1	.	.	2	2	1	3	1	1	1	1	1	1	1	.	2	2	.	1	.	2	1	1	1	.	.	1	1	1	.
3	4	1	.	1	2	2	1	2	.	1	.	3	4	3	3	4	4	4	4	2	2	1	.	.	1	1	1	2	1	.	.
3	3	.	1	2	3	1	1	3	4	6	8	8	9	9	9	9	6	3	2	1	1	1	2	1	1	.	.	2	.	.	.
1	.	3	2	1	2	1	1	3	3	5	5	4	3	.	.	.	7	5	3	2	2	1	.	1	.	.	1	.	1	1	.
1	3	1	1	2	2	2	1	3	4	8	6	5	4	.	2	3	5	5	2	3	1	2	1	1	1	2	1	2	.	2	.
.	2	1	1	.	2	3	.	2	6	9	5	1	.	.	2	3	5	9	2	3	1	3	1	1	2	3	2	.	3	2	.
.	2	2	1	2	5	3	1	2	3	4	7	.	1	.	.	.	4	8	3	.	1	3	1	.	1	3	1	2	2	1	.
.	1	2	2	2	4	1	1	2	4	1	8	8	9	9	9	9	8	5	.	2	4	.	.	1	1	1	.	1	1	2	.
1	2	3	3	2	1	2	2	1	2	1	2	3	3	4	4	4	2	1	2	2	2	2	1	2	1	.	.	1	2	2	.
1	2	1	1	1	.	1	1	1	1	1	2	2	2	.	1	2	2	2	2	3	3	1	2	1	1	.	.	2	1	2	.
.	2	2	.	1	2	2	1	1	.	.	1	2	2	1	2	3	.	1	.	2	3	1	1	.	1	3	2	.	2	1	.
1	2	1	1	1	2	2	2	1	2	2	.	1	.	.	3	2	1	.	2	1	2	1	.	1	1	3	2	.	1	2	.
.	1	1	.	2	.	2	3	2	.	1	1	1	1	2	.	1	.	.	1	.	.	1	1	2	1	1	.	1	1	1	.
2	2	1	.	.	1	1	1	1	1	.	2	.	1	.	2	1	1	.	1	2	1	1	1	.	1	2	.	1	.	.	.
3	2	.	.	1	2	1	1	.	1	3	2	1	1	2	2	2	1	1	2	3	2	2	2	1	.	1	2	1	2	1	.
1	1	2	2	.	.	2	.	2	1	2	1	1	.	2	3	1	3	2	1	2	4	.	.	.	1	1	2	2	2	2	.
1	2	2	3	1	.	1	2	2	1	2	1	1	.	2	1	2	2	1	1	.	3	2	2	2	.	1	1	.	1	1	.
2	2	1	2	.	2	3	3	1	2	4	2	.	1	2	1	.	.	.	2	3	1	1	2	3	1	1	2	2	1	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

SAMPLE NO. 88 RUN NO. 90

EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

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. . 1 1 1 . . . . . 1 1 . 1 . . . . . . . . 1 . . . . . . . . .
. 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . 1 . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . 1 . . . . . . . . . .
1 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 . . . . . . . . . . 1 . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . 1 . . . . . . . . . . .
. . . . . . . . . . . . . . . . 1 . . . . . . . . . . 1 . . . .
. . . . . . . . . . . . . . . . 1 . . . . . . . . . . . . . . .
. . . . 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
. 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. 1 . . . . . . . . . . 1 1 . 1 1 1 1 1 . . . . . . . . . . . .
1 . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . .
. . . . . . . . . . 1 1 1 1 . . . 1 1 . . . . . . . . . . . . .
. . . . . . . . 1 1 1 1 1 1 . . 1 1 1 . . . . . . . . . . . . .
. . . . . . . . . 1 1 1 . . . . 1 1 1 . . . 1 . . . . . . . . .
. . . . . 1 1 . . . 1 1 . . . . . 1 1 . . . . . . . . . . . . .
. . . . . 1 . . . 1 . 1 1 1 1 1 1 1 1 . . 1 . . . . . . . . . .
. . 1 1 . . . . . . . . . 1 1 1 1 . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . 1 1 . . . . . . . . . .
. . . . . . . . . . . . . . . . 1 . . . . 1 . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . 1 . . . . . . . . . 1 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 1 . . . 1 . . . . . . . . . .
. . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . 1 . . 1 . . . . . . . . . 1 . . . 1 . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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~~SAMPLE NO. 88~~ RUN NO. 90

DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

6	6	8	8	8	6	6	6	5	6	8	8	7	6	7	6	7	5	6	6	7	9	6	7	5	5	7	6	7	6	6	6
4	6	4	6	4	5	6	4	5	6	4	4	5	4	4	6	4	5	5	6	6	6	5	4	5	5	6	6	5	5	6	5
4	6	3	5	4	4	5	4	4	6	5	4	4	4	4	4	4	6	5	6	6	3	4	4	4	5	4	5	5	4	5	4
4	5	5	5	6	6	5	4	6	6	5	6	4	4	5	5	4	5	5	4	3	4	5	6	5	6	5	4	5	4	6	6
5	5	5	4	4	7	5	4	5	4	5	5	4	6	5	5	4	6	6	5	6	6	5	4	4	4	5	5	5	4	6	4
6	2	5	6	4	4	5	5	4	4	5	4	6	4	5	5	5	4	4	4	5	4	2	5	4	4	4	5	4	4	5	6
6	4	6	5	7	6	5	5	6	6	5	7	6	5	5	5	5	4	6	4	6	5	4	4	5	4	6	4	5	5	5	6
6	4	5	5	5	6	6	5	5	5	6	5	3	6	6	4	5	5	6	4	6	4	4	4	4	5	4	5	5	6	6	4
5	5	5	5	5	6	4	6	4	5	5	5	5	5	6	6	5	5	4	5	5	4	6	5	5	6	3	5	4	4	5	4
4	6	4	5	4	6	6	4	4	7	6	5	6	6	5	6	5	5	7	6	7	8	5	4	4	4	5	4	6	4	4	6
6	5	4	6	5	5	6	6	5	6	6	6	6	6	6	5	8	8	5	7	6	4	6	6	4	5	5	5	7	6	5	6
5	6	5	6	4	4	6	5	5	4	5	7	6	5	7	6	4	7	6	6	6	7	6	6	6	4	4	5	5	6	5	4
4	5	6	6	6	7	8	6	7	6	6	5	6	7	7	7	6	7	6	5	5	6	4	6	6	6	5	6	4	6	6	6
5	4	6	6	6	5	4	6	5	4	6	6	6	7	6	6	6	6	4	5	5	5	7	6	7	5	4	4	5	6	5	5
5	4	7	6	6	6	6	6	6	7	6	8	6	5	7	7	6	6	7	6	4	6	5	5	6	6	5	5	5	4	6	5
7	4	6	6	6	5	8	7	5	6	6	6	7	9	9	9	9	9	9	8	7	7	6	6	6	6	6	5	6	5	5	5
6	5	6	7	7	6	7	6	6	8	9	1	4	8	8	8	8	8	8	7	6	6	6	5	5	6	4	6	4	4	5	5
6	6	4	5	7	8	8	6	5	7	6	8	2	1	8	8	8	8	1	9	8	7	5	5	5	5	6	5	4	5	6	6
5	6	4	6	6	5	7	6	5	8	8	8	8	8	8	8	3	3	1	7	7	5	6	4	4	6	6	5	6	5	4	6
6	5	4	5	5	6	4	6	6	5	6	8	4	8	8	8	8	8	8	9	8	6	6	4	5	6	4	4	5	7	4	4
5	6	6	6	6	8	9	6	7	6	8	9	8	4	8	8	8	8	1	6	6	8	6	4	5	5	6	6	5	5	5	5
6	5	6	4	6	5	7	8	5	5	8	7	9	8	9	9	9	9	6	6	6	6	4	6	5	6	6	5	6	5	6	7
6	5	7	7	7	7	6	5	6	6	6	7	6	6	6	6	6	5	7	4	5	5	5	5	4	5	5	6	5	4	5	6
5	5	6	6	6	6	6	7	5	7	6	6	5	8	6	6	5	5	6	6	6	8	6	6	6	5	6	5	6	6	5	6
4	5	4	6	6	5	5	7	7	6	7	6	6	6	5	6	8	6	5	6	6	4	5	5	5	6	6	4	6	6	5	5
5	6	5	5	6	7	4	5	7	5	5	6	6	5	6	5	6	6	6	5	5	6	6	5	5	5	6	5	6	6	6	6
5	6	5	6	5	5	7	4	6	5	5	4	6	6	6	5	5	7	5	6	6	6	6	5	6	6	6	6	5	6	7	6
4	7	5	6	5	5	5	6	6	6	5	5	6	6	5	6	6	6	6	5	5	4	6	5	6	6	5	5	6	6	6	6
6	7	6	5	6	7	6	4	6	6	6	8	5	5	5	7	4	7	7	6	7	7	6	4	6	5	6	5	7	5	8	6
6	6	6	5	7	6	6	7	5	5	6	5	7	4	6	6	5	4	5	5	6	5	4	6	5	6	6	5	6	6	5	6
6	5	7	6	8	6	6	7	7	6	6	8	6	6	5	7	7	6	6	6	4	6	7	6	4	6	6	7	6	6	6	6
7	6	6	6	7	7	5	5	5	6	4	7	6	6	6	6	6	6	6	6	6	8	6	6	4	7	6	5	6	4	6	6

SAMPLE NO. 88   RUN NO. 90

CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . 1 4 5 5 9 9 5 8 . . . . . . . . . . . . .
. . . . . . . . . . . 8 2 1 9 9 9 5 1 . . . . . . . . . . . . .
. . . . . . . . . . 8 9 9 5 9 9 3 3 1 . . . . . . . . . . . . .
. . . . . . . . . . . 8 4 5 9 8 5 5 9 . . . . . . . . . . . . .
. . . . . . . . . . . . 9 4 9 5 5 9 1 . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 88     RUN NO.  90

CORRELATION REFERENCE MATRIX

13 913161213121311121311111121312
151312131213131213121412151 21111
111311131311121213111 0 913121213
111212121513131014151613141 21313
121211 91317191821211171617171113
 91115162330283130292622171 51511
151113172229273130303026231 91511
151617182931313131302527171 31212
101114142230303030303030211 31711
151613131928302630272829161 21312
111311101414161618161213151 11112
111212131313131412131013111 31112
151210111313111311131314141 31110
111010131111313121313101313121110
131111141010131212111212101 01111
131211131010131010111310131 01212

TRACKING ERRORS

EDGE ERRORS XM= -1.0409    YM=  1.9396     XC=  -.0409   YC=  -.6229

CENTROID ERRORS XM= -1.1646   YM=  3.0318     XC=  -.1646   YC=   .4693

CORRELATION ERRORS XM= -1.1583   YM=  3.0586     XC=  -.1583   YC=   .4961

FRAME OFFSETS   -1    3     INPUT INCR. ERRORS        0.0000       -.4375

FINAL SEARCH CORRELATIONS -
6.38E+02   5.44E+02   7.28E+02   3.46E+02   2.28E+02   4.18E+02   5.62E+02   4.46E+02   6.44E+02
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STATISTICAL DATA

		RESOLUTION ELEMENTS			REGRESSION COEF	
CENTROID - X AXIS	MEAN	-5.721010E-02	RMS	2.124516E-01	BETA	5.427744E-04
CENTROID - Y AXIS	MEAN	3.113397E-01	RMS	1.988209E-01	BETA	9.925996E-03
RADIAL ERROR(RMS)=		.2910	DRIFT DISTANCE=	.8748		
DIG CORR - X AXIS	MEAN	-1.241746E-01	RMS	2.018930E-01	BETA	-4.349913E-04
DIG CORR - Y AXIS	MEAN	2.792015E-01	RMS	2.247196E-01	BETA	1.106327E-02
RADIAL ERROR(RMS)=		.3021	DRIFT DISTANCE=	.9743		
EDGE - X AXIS	MEAN	-5.600614E-01	RMS	3.729557E-01	BETA	-1.890886E-04
EDGE - Y AXIS	MEAN	-3.918464E-01	RMS	3.708143E-01	BETA	9.455070E-03
RADIAL ERROR(RMS)=		.5259	DRIFT DISTANCE=	.8322		

~~TRACKING ERRORS~~

CENTROID - X AXIS

.2055	.1783	.2597	.1818	.2012	.7022	.2233	-.1074	-.0276	-.0477
.0145	-.0927	.0342	-.3178	-.5345	-.3631	-.3716	-.4238	.0092	-.0952
-.2146	.0734	-.0884	.1322	.3426	.3592	.0151	-.1914	.0370	-.0806
-.1304	-.0811	-.0067	.0953	-.1249	-.0539	-.3753	-.4286	-.2989	-.2785
-.3877	-.5215	-.4033	-.4507	-.2774	-.1774	-.3056	-.1839	-.3835	-.0509
-.2094	-.2812	-.3222	-.2382	-.0870	-.2190	-.1415	.3667	.0070	.5463
.0574	-.2072	-.0848	-.1512	-.0231	.0403	-.0599	.2027	.0062	.2834
.1019	.0136	-.3012	.0735	.3222	.1242	.0780	-.0212	-.1378	-.1849
.2130	.0653	.1409	-.0394	.0525	.0957	.0708	-.1787		

CENTROID - Y AXIS

.0547	.1080	.1523	.0917	.0929	.0408	.1753	.1551	.3707	.2878
.1709	.0876	.0481	-.0046	.0531	.2157	-.0466	-.2006	-.0739	.0178
.0073	-.0723	.0433	-.1025	-.0517	-.2403	-.0775	-.0181	.1124	.0641
.1714	.0660	.1778	.1790	-.0224	-.1098	-.0100	-.2264	-.1082	-.1353
-.1288	.0202	.0455	.3011	.3203	.2750	.2202	.1966	.1419	.4365
.5135	.2741	.2076	.5564	.5280	.6309	.7386	.7318	.6269	.6870
.7391	.4714	.6056	.7347	.6939	.7529	.8379	.8032	.9359	.7322
.7291	.7288	.7266	.9757	.7236	.7173	.6688	.5786	.6978	.6161
.6556	.6325	.4737	.5638	.5363	.4673	.4496	.3955		

DIG CORR - X AXIS

.2639	.1563	.1457	-.0166	.1462	.4740	.1631	-.0963	-.0113	-.0725
-.0846	-.0383	.1187	-.2529	-.3310	-.1827	-.4098	-.3058	-.3642	-.2246
-.4380	-.0381	-.0562	-.0483	.2369	.2476	.1915	-.2411	.0185	-.1141
-.3566	.1637	-.3269	-.1284	.1916	-.1202	-.3485	-.5276	-.2071	-.5352
-.3637	-.4456	-.5917	-.5286	-.2798	-.2929	-.1700	-.0893	-.4423	-.3288
-.0810	-.5077	-.6418	-.3066	-.1422	-.3331	-.1004	.1519	-.0450	.2323
.0785	-.3291	-.5077	-.2626	-.0871	-.1765	.0619	.2679	-.0516	.2128
.1318	-.1639	-.1624	-.0763	.2421	-.0213	.1089	-.2122	-.2459	-.0690
.1145	-.1237	-.0861	-.1168	.0671	-.1598	-.2844	-.1583		

DIG CORR - Y AXIS

.0939	.0238	.1331	-.0204	.0699	.1621	.1027	.2384	.3273	.1502
.1345	-.0066	.0450	-.0429	.0137	.0890	.0063	-.0960	-.1251	-.1087
-.0097	-.1637	-.1632	-.0961	-.0391	-.0844	-.0485	-.0967	-.1228	-.0516
-.0793	.0133	.1366	-.0411	-.1048	-.1872	-.0950	-.2018	-.2820	-.1776
-.1856	-.0825	-.0137	.1239	.0471	.0315	.0268	.0234	.1687	.3596
.3231	.2564	.3001	.3906	.5021	.5786	.7349	.8636	.6850	.7663
.7295	.5743	.5595	.8419	.6757	.7738	.8639	.7457	.8941	.7467
.6888	.7163	.7886	.8865	.8831	.7833	.7133	.6492	.7671	.7135
.6726	.6401	.6003	.5257	.4489	.5487	.5182	.4951		

TRACKING ERRORS (Continued)

EDGE - X AXIS

-1.3952	-.9344	-.0371	.4810	.0964	-.9970	-.2440	.2231	-.8408	-1.4750
-.3300	-1.0357	-.1234	-.2607	-1.2367	-1.8605	.5812	-.3618	-2.1334	-.0836
-.4586	-.2557	-1.6421	-.2070	-.8544	-.4456	-.1457	-1.7701	-.5621	-.1545
-.4408	.9012	-1.3767	-.3180	-.6629	-.5788	-1.9576	-.3521	-.6276	-1.3598
-.5150	-1.4271	.5157	-.2906	-.6701	-.1654	.2425	-.8438	-.8438	-.2100
-.6423	-1.1410	-.1837	-1.5014	.4773	-.3390	-1.1721	.5061	-1.3510	1.7238
-2.0450	-.6185	-.8769	-1.0666	.3493	-.0153	-1.0270	-1.5589	-.9209	-.6375
-.0490	-.2696	-.6933	-.7889	-.7313	-.7818	-.1928	-1.0231	-.6855	-.6125
.2828	.0392	-.8410	-1.7152	-.2490	-.1391	-.2348	-.3569		

EDGE - Y AXIS

-.4245	-1.0017	-.6363	-.6904	-1.0994	-.9324	-.9498	-.2732	-.7033	-.0087
.2705	-.6142	-.4200	-.0175	-.2237	-.6495	-1.2378	-.3324	-1.0873	-.6355
-1.4770	-.9944	-.8649	-1.1406	.7844	-1.0238	-1.8951	-.6579	-.6321	-.8050
.8205	-1.6430	-.1398	-.6814	-.6409	-.4661	-1.4088	-1.0209	.0652	-1.9822
-.8516	-.5292	-.7667	-.7206	-.2039	-.6172	-.4419	.0197	-1.0294	-.5833
.1901	.3381	.3788	-.0360	-.0039	.5248	-.2697	-.4262	-.3740	-.8074
.2509	-.2270	.2594	.1339	.8533	-.3329	-.7058	-.1899	.0735	-.0675
-.2396	1.1745	-.4510	-.0229	-1.0464	.0801	-.4795	.5406	-.6155	.1030
.4627	.0437	-.1121	.1725	-.1043	-.8830	.4031	-.3087		

FILTERED TRACKER CATA

CENTROID - X AXIS

0.0000	0.0000	.1818	.2054	.2436	.3904	.4398	.2217	-.0436	-.1391
-.0694	-.0270	-.0025	-.1174	-.3525	-.4841	-.4572	-.3964	-.2251	-.0779
-.0730	-.0601	-.0500	.0299	.1893	.3447	.2747	.0088	-.1279	-.1167
-.0851	-.0856	-.0607	.0203	.0101	-.0451	-.2043	-.3721	-.4176	-.3464
-.3114	-.3977	-.4638	-.4717	-.3838	-.2537	-.2108	-.2090	-.2820	-.2335
-.1763	-.1886	-.2741	-.3043	-.2144	-.1519	-.1371	.0476	.1603	.3312
.2997	.0599	-.1551	-.2130	-.1229	-.0049	.0244	.0801	.0861	.1573
.1750	.1136	-.0970	-.1464	.0584	.2322	.2132	.0643	-.0863	-.1804
-.0566	.0922	.1707	.0926	.0192	.0250	.0693	-.0065		

CENTROID - Y AXIS

0.0000	0.0000	.0980	.1460	.1268	.0723	.0872	.1373	.2543	.3262
.2862	.1630	.0565	-.0007	.0066	.1011	.1030	-.0401	-.1493	-.1075
-.0078	.0093	.0038	-.0382	-.0645	-.1424	-.1593	-.0987	.0293	.1032
.1441	.1243	.1279	.1390	.0866	-.0306	-.0842	-.1387	-.1523	-.1483
-.1298	-.0667	.0140	.1612	.2959	.3412	.2876	.2131	.1569	.2464
.4193	.4521	.3262	.3295	.4555	.6011	.7008	.7472	.7110	.6680
.6803	.6227	.5693	.6110	.6923	.7496	.7955	.8202	.8704	.8438
.7716	.7126	.7053	.8160	.8517	.7928	.6932	.6121	.6161	.6359
.6534	.6465	.5752	.5254	.5165	.5074	.4746	.4249		

DIG CORR - X AXIS

0.0000	0.0000	.1402	.1314	.0927	.2255	.3077	.1625	-.0288	-.1147
-.1046	-.0652	.0235	-.0335	-.2088	-.3002	-.3429	-.3393	-.3481	-.3023
-.3251	-.2413	-.1113	-.0165	.0973	.2129	.2573	.0607	-.0912	-.1408
-.2090	-.1187	-.1199	-.1429	-.0452	.0164	-.1171	-.3877	-.4450	-.4411
-.4036	-.4146	-.4878	-.5524	-.4685	-.3264	-.2020	-.1208	-.2145	-.3384
-.2939	-.3034	-.4637	-.5162	-.3475	-.2199	-.1525	-.0247	.0514	.1326
.1426	-.0404	-.3484	-.4632	-.3054	-.1326	-.0061	.1365	.1402	.1316
.1258	.0274	-.1193	-.1561	.0182	.1195	.1261	-.0278	-.1973	-.2217
-.0599	.0200	-.0221	-.1062	-.0683	-.0579	-.1528	-.2265		

DIG CORR - Y AXIS

0.0000	0.0000	.0717	.0716	.0529	.0827	.1218	.1799	.2618	.2625
.1902	.0683	.0060	-.0241	-.0152	.0321	.0521	-.0059	-.0958	-.1396
-.0934	-.0824	-.1228	-.1440	-.0997	-.0606	-.0466	-.0672	-.1013	-.0994
-.0804	-.0336	.0544	.0656	-.0168	-.1392	-.1725	-.1743	-.2126	-.2309
-.2115	-.1430	-.0589	.0492	.0976	.0776	.0334	.0125	.0705	.2227
.3447	.3478	.3002	.3123	.4103	.5318	.6599	.7911	.8077	.7696
.7280	.6612	.5842	.6482	.7242	.7717	.8096	.8086	.8306	.8121
.7515	.6985	.7190	[illegible]	.8880	.8725	.7817	.6805	.6752	.7112
.7174	.6761	.6221	.5632	.4940	.4831	.5071	.5203		

FILTERED TRACKER DATA (Continued)

EDGE - X AXIS

0.0000	0.0000	-.4792	-.2096	.2263	-.0963	-.4978	-.3554	-.3072	-.8173
-.9990	-.9474	-.5582	-.2512	-.5120	-1.2923	-.9963	-.3168	-.6656	-.9467
-.7745	-.3241	-.6767	-.8375	-.8306	-.5967	-.3385	-.7588	-1.0323	-.7581
-.3384	.2744	-.0719	-.5237	-.7934	-.6943	-1.1062	-1.1291	-.8377	-.8069
-.8209	-1.0467	-.5584	-.1030	-.1315	-.3354	-.1818	-.2566	-.6061	-.6766
-.5746	-.7238	-.6778	-.9003	-.5195	-.1729	-.3926	-.3434	-.5844	.1526
-.1991	-.7391	-1.1291	-1.0878	-.4865	.0571	-.1535	-.9988	-1.4222	-1.1371
-.4462	-.8573	-.2310	-.6445	-.8665	-.8578	-.5595	-.5614	-.6912	-.7516
-.3254	.0944	-.1111	-.9869	-1.1917	-.6573	-.1037	-.0579		

EDGE - Y AXIS

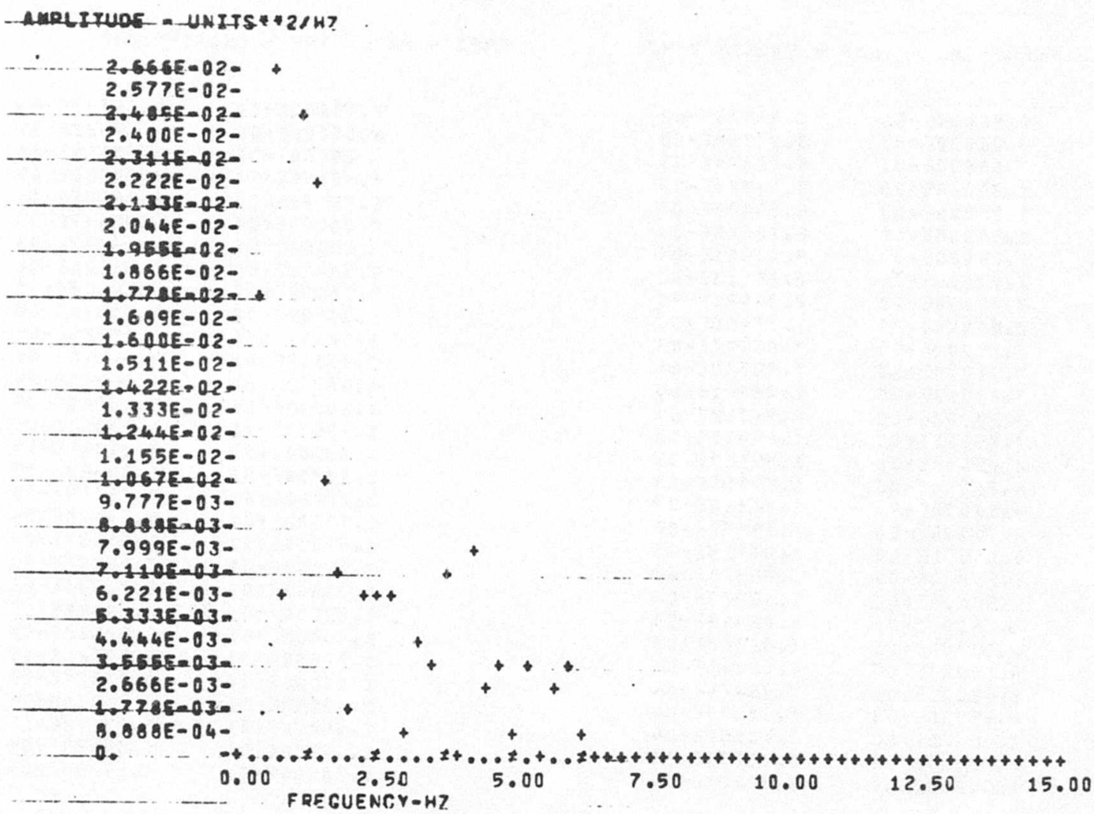
0.0000	0.0000	-.5998	-.9059	-.9805	-.9797	-.9716	-.6882	-.5140	-.2818
.0265	-.0485	-.3355	-.7759	-.2324	-.3098	-.7784	-.8814	-.8858	-.7697
-1.0085	-1.1666	-1.0991	-1.0082	-.3091	-.1478	-.8835	-1.3624	-1.1150	-.7044
-.0012	-.2693	-.5540	-.7362	-.6578	-.5565	-.8345	-1.1143	-.7725	-.9109
-1.1067	-1.0045	-.7171	-.6088	-.4732	-.4399	-.4470	-.2941	-.4536	-.6569
-.4338	.0982	.4687	.3547	.0678	.1099	.0839	-.1596	-.4181	-.6424
-.3851	-.1128	.1410	.2048	.4617	.3111	-.2389	-.5562	-.3362	-.0176
.0034	.3772	.3290	.0730	-.5469	-.5856	-.4295	.0546	.0259	-.0673
.0742	.2285	.1300	.0294	-.0343	-.3711	-.2994	-.1579		

SPECTRAL DENSITY CENTROID - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.74307E-02
5.00000E-01	2.66634E-02
7.50000E-01	5.89258E-03
1.00000E+00	2.48879E-02
1.25000E+00	2.21893E-02
1.50000E+00	1.09203E-02
1.75000E+00	7.50666E-03
2.00000E+00	1.53017E-03
2.25000E+00	6.62983E-03
2.50000E+00	6.07072E-03
2.75000E+00	6.12570E-03
3.00000E+00	6.63588E-04
3.25000E+00	4.30837E-03
3.50000E+00	3.35565E-03
3.75000E+00	6.78029E-03
4.00000E+00	1.36945E-04
4.25000E+00	8.23763E-03
4.50000E+00	2.45332E-03
4.75000E+00	3.21301E-03
5.00000E+00	7.05916E-04
5.25000E+00	3.78788E-03
5.50000E+00	4.40813E-04
5.75000E+00	2.23505E-03
6.00000E+00	3.19016E-03
6.25000E+00	8.12625E-04
6.50000E+00	2.95556E-04
6.75000E+00	1.61273E-04
7.00000E+00	3.69470E-05
7.25000E+00	3.45696E-05
7.50000E+00	3.23848E-04

FREQ - HZ	AMP - UNITS**2/HZ
7.75000E+00	5.21149E-05
8.00000E+00	2.54796E-04
8.25000E+00	1.16400E-04
8.50000E+00	5.85049E-05
8.75000E+00	3.22547E-04
9.00000E+00	9.94479E-05
9.25000E+00	1.85637E-04
9.50000E+00	7.15266E-05
9.75000E+00	3.83259E-05
1.00000E+01	3.72443E-05
1.02500E+01	2.23855E-05
1.05000E+01	4.44021E-05
1.07500E+01	1.51323E-05
1.10000E+01	3.10334E-05
1.12500E+01	1.17113E-05
1.15000E+01	8.77834E-05
1.17500E+01	2.72740E-05
1.20000E+01	2.29327E-05
1.22500E+01	4.32974E-05
1.25000E+01	4.14604E-05
1.27500E+01	4.22178E-05
1.30000E+01	8.62991E-06
1.32500E+01	7.62486E-06
1.35000E+01	1.11961E-05
1.37500E+01	1.05404E-06
1.40000E+01	2.82368E-06
1.42500E+01	3.71023E-05
1.45000E+01	1.33595E-05
1.47500E+01	4.69205E-05
1.50000E+01	1.99306E-06

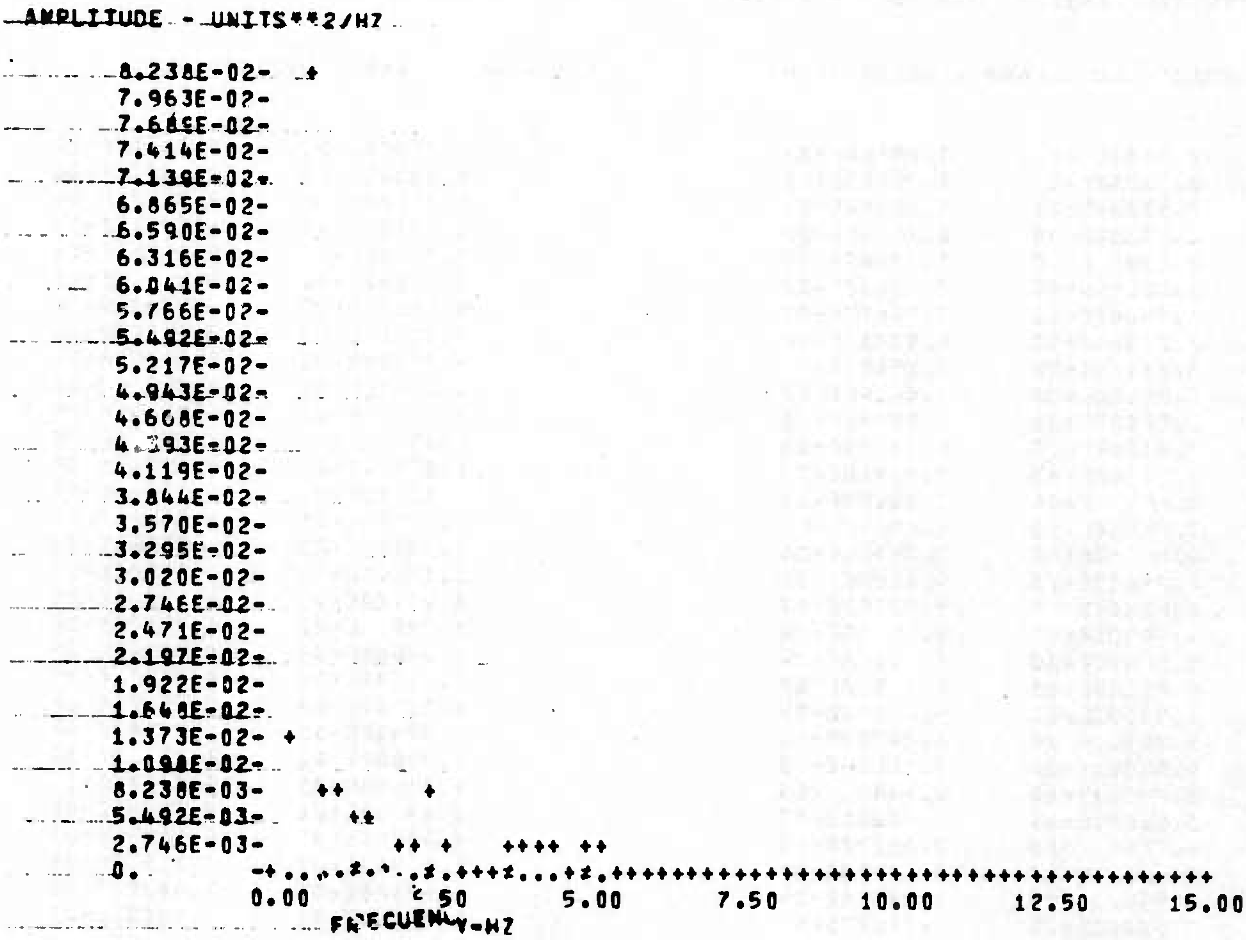
SPECTRAL DENSITY CENTROID - X AXIS



SPECTRAL DENSITY CENTROID - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.23585E-02	7.75000E+00	1.55737E-04
5.00000E-01	3.23769E-02	8.00000E+00	7.19622E-05
7.50000E-01	3.22838E-03	8.25000E+00	3.28719E-05
1.00000E+00	9.44727E-03	8.50000E+00	4.80900E-05
1.25000E+00	6.53498E-03	8.75000E+00	2.86967E-04
1.50000E+00	6.20318E-03	9.00000E+00	1.32557E-05
1.75000E+00	9.41981E-04	9.25000E+00	4.88092E-06
2.00000E+00	2.15113E-03	9.50000E+00	1.67133E-04
2.25000E+00	2.34491E-03	9.75000E+00	2.14407E-05
2.50000E+00	7.32460E-03	1.00000E+01	1.51526E-05
2.75000E+00	3.00597E-03	1.02500E+01	6.67779E-05
3.00000E+00	2.89770E-04	1.05000E+01	4.41446E-05
3.25000E+00	1.76951E-04	1.07500E+01	1.05254E-05
3.50000E+00	2.84035E-04	1.10000E+01	3.03149E-05
3.75000E+00	1.65430E-03	1.12500E+01	1.73091E-05
4.00000E+00	1.89165E-03	1.15000E+01	4.81036E-05
4.25000E+00	1.99610E-03	1.17500E+01	1.64697E-05
4.50000E+00	1.99552E-03	1.20000E+01	7.06759E-05
4.75000E+00	1.72499E-05	1.22500E+01	6.97070E-05
5.00000E+00	1.97711E-03	1.25000E+01	1.51437E-05
5.25000E+00	1.66825E-03	1.27500E+01	2.16192E-05
5.50000E+00	1.16970E-04	1.30000E+01	1.73332E-05
5.75000E+00	4.09466E-05	1.32500E+01	3.90096E-05
6.00000E+00	1.02958E-03	1.35000E+01	2.68628E-05
6.25000E+00	4.42042E-04	1.37500E+01	9.33764E-06
6.50000E+00	3.35424E-04	1.40000E+01	9.37677E-05
6.75000E+00	1.32073E-04	1.42500E+01	1.36816E-05
7.00000E+00	3.71107E-04	1.45000E+01	2.03112E-05
7.25000E+00	2.76252E-06	1.47500E+01	1.85480E-05
7.50000E+00	1.52221E-04	1.50000E+01	8.64264E-05

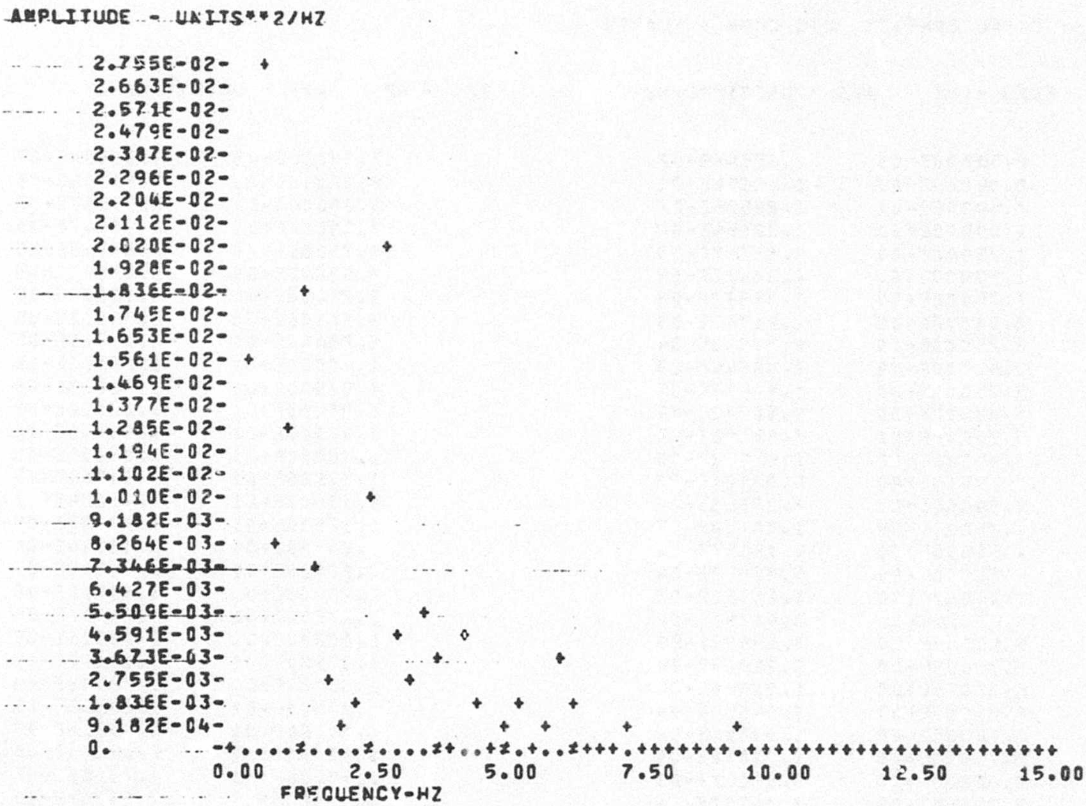
SPECTRAL DENSITY CENTROID - Y AXIS



SPECTRAL DENSITY DIG CORP - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.55814E-02	7.75000E+00	2.60872E-05
5.00000E-01	2.75463E-02	8.00000E+00	2.73018E-04
7.50000E-01	8.28356E-03	8.25000E+00	3.27825E-05
1.00000E+00	1.29195E-02	8.50000E+00	4.50112E-05
1.25000E+00	1.82547E-02	8.75000E+00	4.20647E-04
1.50000E+00	7.21095E-03	9.00000E+00	5.46403E-05
1.75000E+00	3.01457E-03	9.25000E+00	6.59433E-04
2.00000E+00	6.53887E-04	9.50000E+00	3.26113E-04
2.25000E+00	1.89908E-03	9.75000E+00	6.54295E-06
2.50000E+00	1.04144E-02	1.00000E+01	6.34934E-06
2.75000E+00	2.00080E-02	1.02500E+01	4.82439E-05
3.00000E+00	4.13751E-03	1.05000E+01	2.72171E-05
3.25000E+00	2.51869E-03	1.07500E+01	9.99717E-07
3.50000E+00	5.60159E-03	1.10000E+01	3.17128E-07
3.75000E+00	4.04497E-03	1.12500E+01	4.03410E-05
4.00000E+00	2.75819E-04	1.15000E+01	3.35164E-05
4.25000E+00	4.41932E-03	1.17500E+01	3.24920E-05
4.50000E+00	1.62057E-03	1.20000E+01	6.09870E-06
4.75000E+00	2.56115E-04	1.22500E+01	1.25876E-05
5.00000E+00	5.70029E-04	1.25000E+01	8.68140E-05
5.25000E+00	2.21623E-03	1.27500E+01	6.39902E-05
5.50000E+00	9.49601E-05	1.30000E+01	9.56174E-06
5.75000E+00	8.24708E-04	1.32500E+01	1.27687E-05
6.00000E+00	3.81436E-03	1.35000E+01	7.09319E-06
6.25000E+00	2.14820E-03	1.37500E+01	5.20720E-06
6.50000E+00	8.76351E-05	1.40000E+01	2.75385E-06
6.75000E+00	2.26172E-05	1.42500E+01	6.90252E-05
7.00000E+00	7.68479E-05	1.45000E+01	5.32532E-08
7.25000E+00	7.89961E-04	1.47500E+01	7.48223E-06
7.50000E+00	3.17177E-05	1.50000E+01	3.19132E-05

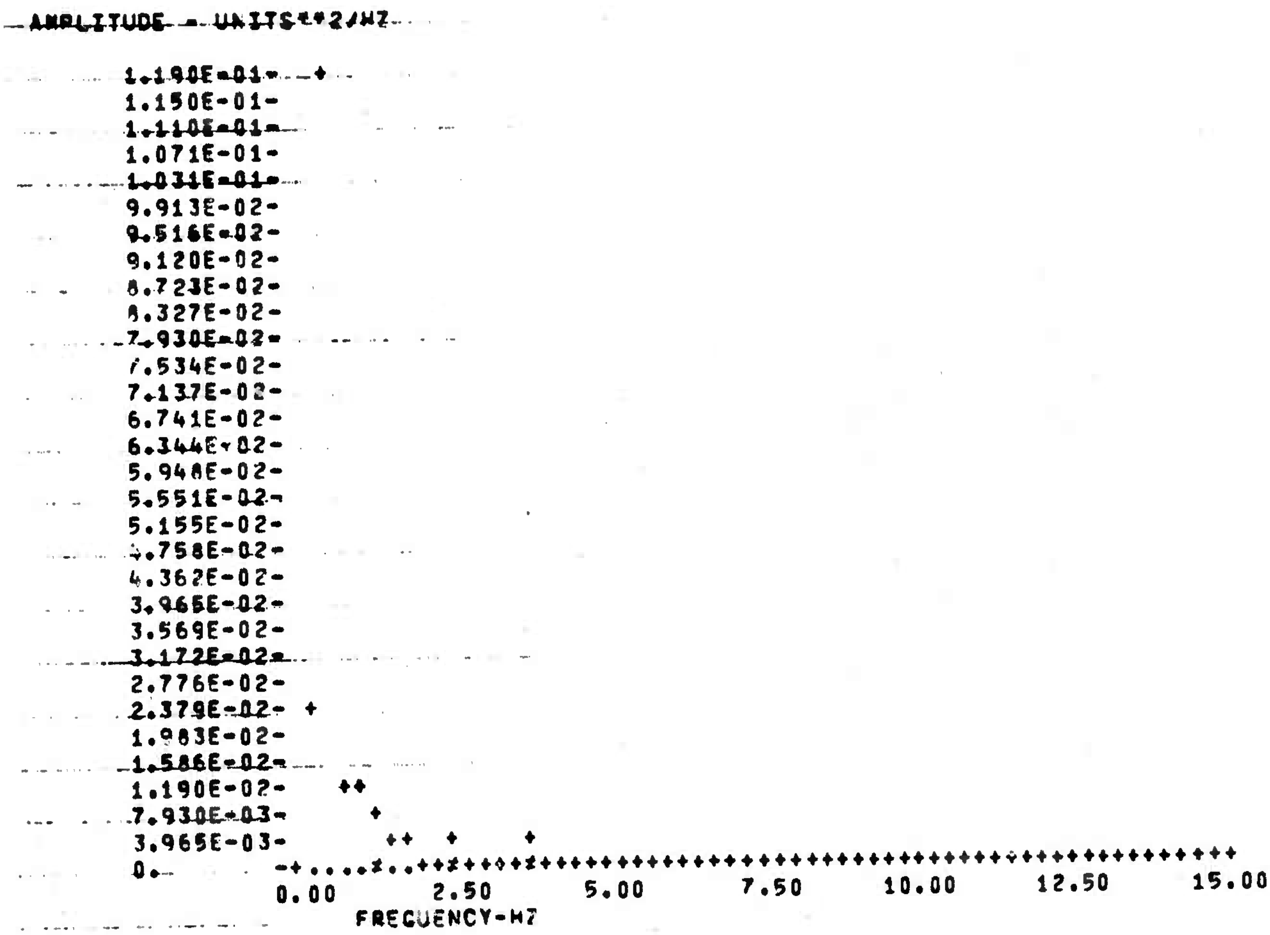
SPECTRAL DENSITY DIG CORR - X AXIS



SPECTRAL DENSITY DIG CORR - Y AXIS

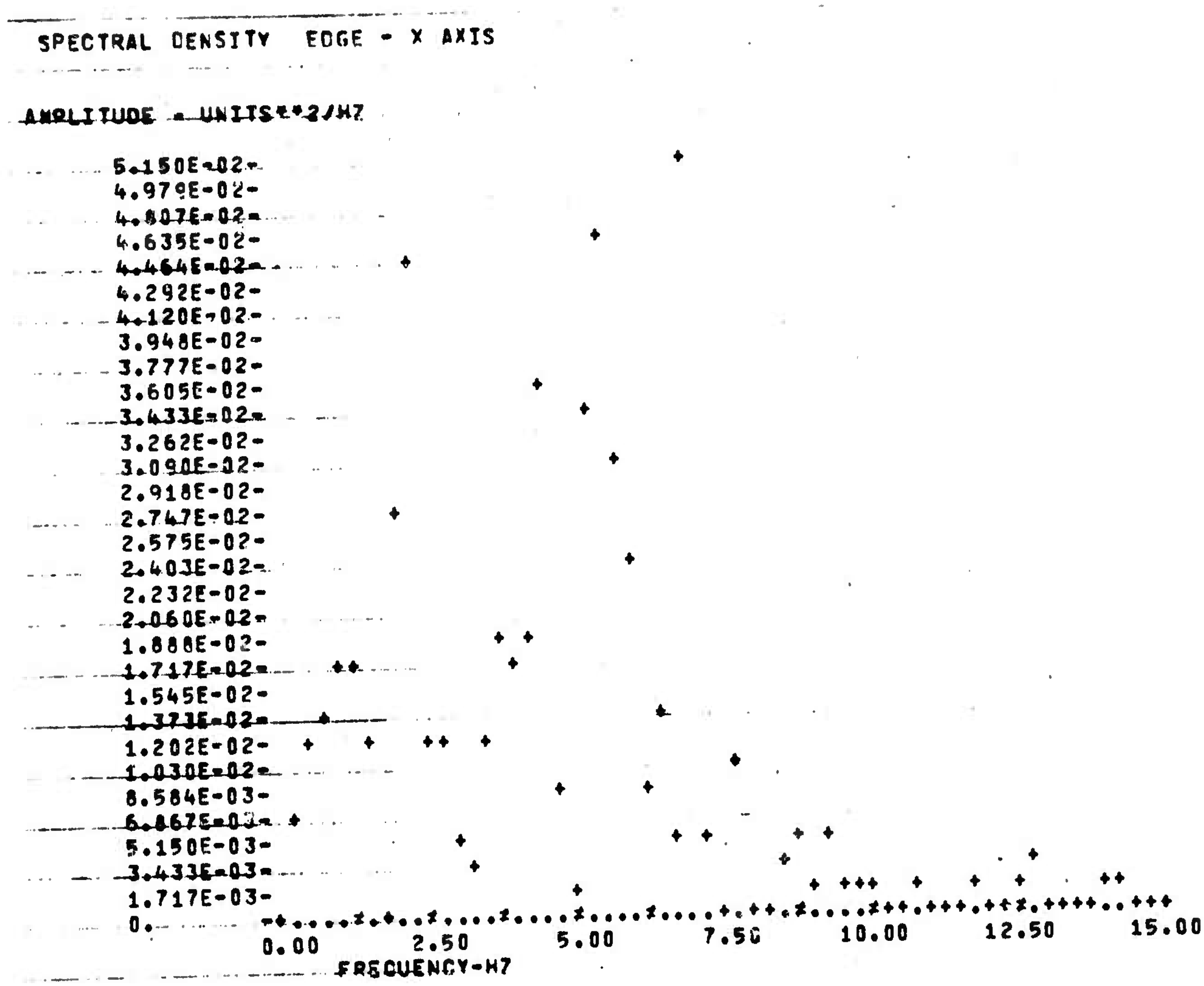
FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	2.35649E-02	7.75000E+00	3.02604E-07
5.00000E-01	1.19956E-01	8.00000E+00	9.55364E-06
7.50000E-01	1.26526E-02	8.25000E+00	3.50627E-07
1.00000E+00	1.02859E-02	8.50000E+00	4.99647E-05
1.25000E+00	9.17757E-03	8.75000E+00	7.09545E-05
1.50000E+00	2.38521E-03	9.00000E+00	1.27048E-05
1.75000E+00	2.85992E-03	9.25000E+00	2.12838E-05
2.00000E+00	1.61783E-03	9.50000E+00	6.56162E-05
2.25000E+00	6.33540E-04	9.75000E+00	4.01365E-05
2.50000E+00	2.89544E-03	1.00000E+01	1.25266E-05
2.75000E+00	1.67583E-03	1.02500E+01	2.71673E-05
3.00000E+00	9.50981E-05	1.05000E+01	6.02190E-05
3.25000E+00	3.63181E-05	1.07500E+01	1.66448E-05
3.50000E+00	1.67053E-03	1.10000E+01	2.09236E-05
3.75000E+00	5.92101E-03	1.12500E+01	4.14561E-05
4.00000E+00	8.33363E-04	1.15000E+01	4.41824E-05
4.25000E+00	1.09734E-03	1.17500E+01	7.77937E-07
4.50000E+00	5.16557E-04	1.20000E+01	3.32544E-05
4.75000E+00	5.32952E-04	1.22500E+01	8.91402E-05
5.00000E+00	1.68062E-03	1.25000E+01	3.90717E-06
5.25000E+00	3.41791E-04	1.27500E+01	7.66401E-06
5.50000E+00	8.65090E-05	1.30000E+01	2.12906E-05
5.75000E+00	2.20098E-04	1.32500E+01	5.29172E-05
6.00000E+00	1.83866E-04	1.35000E+01	2.76585E-06
6.25000E+00	2.94559E-04	1.37500E+01	1.00365E-05
6.50000E+00	1.49611E-04	1.40000E+01	2.95564E-05
6.75000E+00	1.01008E-05	1.42500E+01	2.82171E-05
7.00000E+00	5.59667E-05	1.45000E+01	6.70209E-06
7.25000E+00	1.14767E-04	1.47500E+01	2.69301E-05
7.50000E+00	1.91805E-04	1.50000E+01	5.49790E-05

SPECTRAL DENSITY DIG CORR - Y AXIS



SPECTRAL DENSITY EDGE - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	6.74126E-03
5.00000E-01	1.17391E-02
7.50000E-01	1.43065E-02
1.00000E+00	1.65513E-02
1.25000E+00	1.79256E-02
1.50000E+00	1.15509E-02
1.75000E+00	7.39832E-04
2.00000E+00	2.67083E-02
2.25000E+00	4.53270E-02
2.50000E+00	1.25904E-02
2.75000E+00	1.12050E-02
3.00000E+00	5.02618E-03
3.25000E+00	2.85511E-03
3.50000E+00	1.28252E-02
3.75000E+00	1.87388E-02
4.00000E+00	1.66559E-02
4.25000E+00	1.92498E-02
4.50000E+00	3.69082E-02
4.75000E+00	8.05084E-03
5.00000E+00	2.36958E-03
5.25000E+00	3.41030E-02
5.50000E+00	4.61339E-02
5.75000E+00	3.12100E-02
6.00000E+00	2.44541E-02
6.25000E+00	9.26372E-03
6.50000E+00	1.36845E-02
6.75000E+00	5.73443E-03
7.00000E+00	5.15021E-02
7.25000E+00	4.45523E-03
7.50000E+00	5.78639E-04
7.75000E+00	1.11587E-02
8.00000E+00	7.85706E-04
8.25000E+00	3.94361E-04
8.50000E+00	3.12678E-03
8.75000E+00	4.53141E-03
9.00000E+00	1.61311E-03
9.25000E+00	4.63861E-03
9.50000E+00	9.75808E-04
9.75000E+00	2.12444E-03
1.00000E+01	9.45369E-04
1.02500E+01	2.72117E-04
1.05000E+01	5.38937E-04
1.07500E+01	1.11895E-03
1.10000E+01	6.07108E-04
1.12500E+01	2.43696E-04
1.15000E+01	2.31841E-04
1.17500E+01	9.09618E-04
1.20000E+01	4.59067E-04
1.22500E+01	6.56418E-04
1.25000E+01	1.01784E-03
1.27500E+01	3.22562E-03
1.30000E+01	6.08506E-04
1.32500E+01	5.43742E-04
1.35000E+01	2.53442E-04
1.37500E+01	4.09488E-04
1.40000E+01	1.52036E-03
1.42500E+01	1.02147E-03
1.45000E+01	5.60019E-05
1.47500E+01	1.49735E-04
1.50000E+01	1.16739E-04

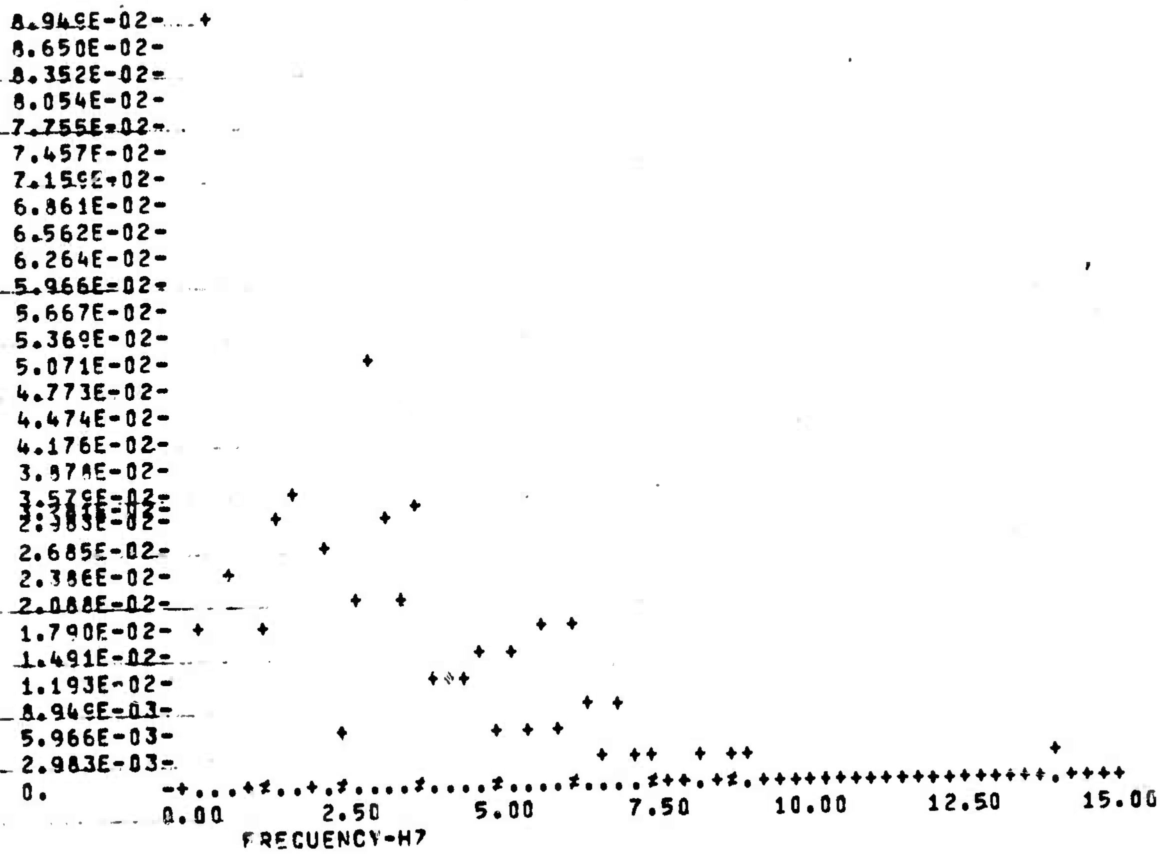

SPECTRAL DENSITY EDGE - X AXIS
AMPLITUDE - UNITS**2/HZ
5.150E-02
4.979E-02
4.807E-02
4.635E-02
4.464E-02
4.292E-02
4.120E-02
3.948E-02
3.777E-02
3.605E-02
3.433E-02
3.262E-02
3.090E-02
2.918E-02
2.747E-02
2.575E-02
2.403E-02
2.232E-02
2.060E-02
1.888E-02
1.717E-02
1.545E-02
1.373E-02
1.202E-02
1.030E-02
8.584E-03
6.867E-03
5.150E-03
3.433E-03
1.717E-03
0.
0.00
2.50
5.00
7.50
10.00
12.50
15.00
FREQUENCY-HZ

SPECTRAL DENSITY EDGE - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.67894E-02
5.00000E-01	8.94854E-02
7.50000E-01	2.24474E-02
1.00000E+00	1.35714E-03
1.25000E+00	1.79756E-02
1.50000E+00	3.04282E-02
1.75000E+00	3.71914E-02
2.00000E+00	1.02762E-03
2.25000E+00	2.73369E-02
2.50000E+00	5.49302E-03
2.75000E+00	1.98293E-02
3.00000E+00	5.12264E-02
3.25000E+00	2.95331E-02
3.50000E+00	2.09492E-02
3.75000E+00	3.17967E-02
4.00000E+00	1.31587E-02
4.25000E+00	1.19995E-02
4.50000E+00	1.24421E-02
4.75000E+00	1.35665E-02
5.00000E+00	7.00492E-03
5.25000E+00	1.60903E-02
5.50000E+00	4.77208E-03
5.75000E+00	1.65153E-02
6.00000E+00	4.80869E-03
6.25000E+00	1.64735E-02
6.50000E+00	9.79437E-03
6.75000E+00	4.11725E-03
7.00000E+00	9.97224E-03
7.25000E+00	3.74111E-03
7.50000E+00	1.77123E-03
7.75000E+00	1.08795E-03
8.00000E+00	9.72357E-04
8.25000E+00	1.72746E-03
8.50000E+00	1.16671E-03
8.75000E+00	3.47685E-03
9.00000E+00	3.17295E-03
9.25000E+00	5.12993E-04
9.50000E+00	1.19234E-04
9.75000E+00	1.22131E-03
1.00000E+01	2.47499E-04
1.02500E+01	8.60789E-04
1.05000E+01	4.76686E-04
1.07500E+01	1.01176E-03
1.10000E+01	1.02397E-03
1.12500E+01	6.19018E-04
1.15000E+01	1.00290E-04
1.17500E+01	3.64675E-04
1.20000E+01	6.03799E-04
1.22500E+01	4.02572E-04
1.25000E+01	1.39188E-04
1.27500E+01	2.10647E-04
1.30000E+01	1.00889E-04
1.32500E+01	2.73577E-04
1.35000E+01	3.73399E-04
1.37500E+01	2.70606E-04
1.40000E+01	1.61315E-03
1.42500E+01	1.78185E-05
1.45000E+01	5.07634E-04
1.47500E+01	2.72548E-04
1.50000E+01	1.20838E-04

SPECTRAL DENSITY EDGE - Y AXIS

AMPLITUDE - UNITS**2/HZ



CDC 6600 CSP Printout VII

Reference Program: Processing of IR data for aircraft target in narrow field of view

Tracking Program: Run no. 92 using above referenced data

```
DIGITAL CORRELATION TRACKER - REFERENCING PROGRAM

PROCESS 95 PICTURES
SEARCH WINDOW IS 16 X  16
STARTING TARGET COORDINATES ARE (44,45)
TAPE OUTPUT OPTION IS 1

CONTRAST .......NEG
```

COORDINATE ERROR ANALYSIS

STARTING COORDINATES * X= 45.00
Y= 44.00

****

NPIX	X ERROR	Y ERROR
1	0.00	0.00
4	-.50	-.19
7	.31	-.13
10	-.31	-.13
13	.81	.06
16	-.50	-.31
19	.81	-.13
22	.31	-.44
25	.44	-.25
28	.19	-.63
31	.63	-.56
34	0.00	-.69
37	.50	-.44
40	-.13	-.63
43	1.75	-.56
46	.88	-.88
49	1.56	-.50
52	.38	-.75
55	2.00	-.63
58	1.00	-1.06
61	1.56	-1.06
64	.81	-1.38
67	1.44	-1.63
70	1.31	-1.81
73	1.94	-1.81
76	1.50	-2.13
79	1.50	-2.25
82	.81	-2.50
85	1.63	-2.81
88	1.25	-3.00
91	2.56	-3.19
94	1.88	-3.44

NPIX	X ERROR	Y ERROR
2	-.56	-.19
5	.13	-.06
8	[illegible]	-.19
11	.94	.06
14	-.56	-.19
17	.75	-.13
20	.50	-.44
23	.94	-.25
26	.06	-.56
29	.56	-.44
32	0.00	-.69
35	.81	-.56
38	-.06	-.63
41	1.19	-.44
44	1.06	-.81
47	2.13	-.75
50	1.81	-.69
53	1.63	-.50
56	1.50	-.94
59	1.69	-.94
62	1.75	-1.25
65	1.44	-1.50
68	1.06	-1.75
71	1.81	-1.75
74	1.56	-1.94
77	1.69	-2.19
80	1.94	-2.38
83	1.56	-2.56
86	1.94	-2.94
89	2.44	-2.94
92	1.75	-3.31
95	2.56	-3.31

NPIX	X ERROR	Y ERROR
3	-.06	-.13
6	-.38	-.31
9	[illegible]	0.00
12	-.50	-.13
15	.69	0.00
18	.13	-.38
21	1.00	-.25
24	.69	-.44
27	.63	-.38
30	.06	-.69
33	.50	-.56
36	-.19	-.69
39	.88	-.31
42	.50	-.75
45	1.69	-.69
48	.75	-.69
51	1.00	-.56
54	.81	-.75
57	2.19	-.81
60	1.06	-1.19
63	1.44	-1.19
66	1.00	-1.69
69	1.75	-1.69
72	1.38	-1.88
75	2.00	-2.06
78	1.06	-2.19
81	1.31	-2.44
84	1.00	-2.81
87	1.75	-2.94
90	1.81	-3.06
93	3.13	-3.19

SIGNAL/NOISE DETERMINATION

SAMPLE	SIGNAL LEVEL	NOISE LEVEL	S/N
1	16.95	3.68	4.61
2	17.00	3.93	4.32
3	17.18	5.12	3.36
4	16.79	4.81	3.49
5	16.07	4.93	3.26
6	16.17	4.77	3.39
7	15.49	5.99	2.58
8	15.31	4.67	3.28
9	14.71	5.78	2.54

RESULTANT SIGNAL/NOISE = 3.426

TRACKING RUN NO. 92

```
X DIMENSION = 16      Y DIMENSION = 16
X CENTER = 32         Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
  0 FRAMES SKIPPED,  95 FRAMES PROCESSED
FREQUENCY =  30.00
5 INPUT BITS USED
ICOLPS = 0     IOFF = 0
SCALOF =    4.00     SFACX =   5.00     SFACY =   5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT 10 FRAMES(SKIP)
LINEAR PROCESSING ABOVE THRESHOLD OF - 20 FOR CENTROID TRACKER
```

```
CENTROID - X AXIS  GAIN =     .55573

CENTROID - Y AXIS  GAIN =     .79986

DIG CORR - X AXIS  GAIN =    1.00000

DIG CORR - Y AXIS  GAIN =    1.00000

EDGE - X AXIS      GAIN =     .06151

EDGE - Y AXIS      GAIN =     .32627
```

SAMPLE NO. 94   RUN NO. 92

INPUT PICTURE (X OFFSET = 4, Y OFFSET = 1)

INPUT DATA DIVIDED BY 2

```
. 1 . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . .
. 6 4 2 1 . . . . . . 1 . . . . . . . . . . . . . . . . . . . .
. 8 6 4 . 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
. 8 8 5 3 4 3 . . . . . . . . . . . . . . . . . . . . . . . . .
. Z 2 9 8 5 2 . . . . . . . . . . . . . . . . . . . . . . . . .
. 9 # # 7 5 5 3 3 1 1 . . . . . . . . . . . . . . . . . . . . .
. 8 Z Z Z Z # 7 5 3 1 . . . . . . . . . . . . . . 1 . . . . . .
. 6 8 9 Z Z 7 9 6 4 2 3 . . . . . . . . . 2 3 . 1 , 2 . . . . .
. 2 2 6 9 9 Z B 9 6 6 2 1 . . . . . 1 4 7 6 3 5 4 2 1 . . . . .
. . 3 4 7 9 # 8 8 7 6 4 5 1 . 2 . 3 8 Z 2 9 8 8 8 6 4 . . . . .
. . . . 3 6 9 Z B B Z 8 4 3 2 . . 3 4 # Z K K Z 9 7 3 2 . . . .
. . . 1 2 4 8 9 Z Z Z 2 6 6 3 2 4 8 Z K B K Z K # 6 3 5 . . . .
. . . . . 1 3 4 9 8 8 Z K Z 8 6 5 7 9 Z B B B K B Z 9 7 1 . . .
. . . . . . 1 3 7 9 Z Z 2 8 6 Z 9 # K B Z # Z K B B 9 5 1 . . .
. . . . . . . . 5 8 9 Z B 9 B Z # 9 # Z Z Z B B K B 9 5 4 . . .
. . . . . . . 1 2 4 8 8 Z Z 9 9 8 8 8 Z Z B B B B 8 6 1 . . . .
. . . . . . . . . 3 2 3 8 Z # Z 8 9 9 8 8 Z 7 8 Z 8 4 3 . . . .
. . . . . . . . . 1 4 3 7 8 # # Z 9 9 Z Z # 7 8 3 1 . . . . . .
. . . . . . . . . . 1 3 4 6 8 # # # # Z # 8 6 4 1 . . . . . . .
. . . . . . . . . . . 3 4 8 8 Z 8 Z Z # 9 8 7 4 4 1 . . . . . .
. . . . . . . . . . . 3 5 4 7 8 9 Z 2 Z 2 2 Z 9 8 3 1 . . . . .
. . . . . . . . . . . 4 6 9 8 6 6 8 6 9 # Z # # 8 6 . 3 . . . .
. . . . . . . . . . 3 4 6 4 3 3 3 3 6 8 8 Z K B Z 8 8 5 1 . . .
. . . . . . . . . 6 7 9 8 4 . 2 . 2 4 4 4 7 9 8 Z 8 7 5 4 3 . .
. . . . . . . 1 1 4 7 5 4 3 . . . . . . 2 3 6 # # Z # # 8 4 2 .
. . . . . . 1 3 6 8 8 3 . . . . . . . . . 1 3 6 8 9 9 8 8 4 3 1
. . . . . . 2 4 6 5 2 . . . . . . . . . . . . 1 3 6 9 # Z 9 9 6
. . . . . 2 6 6 5 2 1 . . . . . . . . . . . . . 3 3 5 8 # 8 9 5
. 1 . . 3 3 4 5 3 1 1 . . . . . . . . . . . . . . . . 4 7 9 Z #
. 1 2 4 7 5 5 . . . . . . . . . . . . . . . . . . . . 2 2 6 5 9
. 6 5 6 4 3 2 . 2 . . . . . . . . . . . . . . . . . . . . 1 3 7
. 7 8 7 5 3 . . . . . . . . . . . . . . . . . . . . . . 3 4 6
```

SAMPLE NO. 94   RUN NO. 92

VIDEO GRADIENTS

INPUT DATA DIVIDED BY 2

6	7	5	2	1	.	.	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	4	3	4	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	2	3	5	5	5	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	6	7	6	4	2	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6	3	3	3	3	3	5	5	4	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	3	3	5	9	9	8	4	4	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
1	6	5	3	1	5	1	4	2	4	3	3	.	.	.	.	.	.	.	.	2	4	3	1	.	1	2	.	.	.	.	.
7	7	8	5	2	2	7	7	5	5	3	3	1	.	.	.	.	1	4	8	7	3	4	6	4	1	3	.	.	.	.	.
2	3	3	5	2	3	5	5	3	.	5	5	5	1	2	2	3	9	2	8	7	7	6	5	7	6	5	.	.	.	.	.
.	3	6	7	6	4	2	7	9	9	8	3	4	3	.	2	5	5	7	3	3	7	7	4	3	4	4	2	.	.	.	.
.	.	1	2	4	5	4	4	3	2	3	9	4	4	3	5	9	9	8	6	2	3	1	5	5	5	2	6	.	.	.	.
.	.	1	2	5	7	7	7	4	5	4	5	8	8	7	4	4	4	5	4	.	5	4	4	8	1	6	9	1	.	.	.
.	.	.	.	1	3	3	7	1	4	2	3	6	5	3	7	5	8	6	1	4	6	2	1	3	7	5	8	2	.	.	.
.	.	.	.	.	1	4	8	4	4	1	2	7	7	6	2	.	5	5	2	1	3	3	.	1	9	6	5	4	.	.	.
.	.	.	.	.	.	1	5	6	5	4	5	3	2	5	3	2	2	3	.	3	2	2	1	6	8	8	7	4	.	.	.
.	.	.	.	.	.	1	2	5	6	8	8	3	3	3	3	1	2	2	5	7	8	9	8	7	5	5	3	.	.	.	.
.	.	.	.	.	.	.	.	3	2	1	6	5	3	1	2	2	.	2	4	2	6	1	6	2	8	6	3	.	.	.	.
.	.	.	.	.	.	.	.	1	4	3	4	3	3	2	1	2	1	2	.	2	4	3	7	3	1	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	1	4	2	5	2	4	2	3	3	1	2	2	3	3	2	4	1	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	4	2	3	4	4	2	4	1	2	2	5	7	8	7	7	3	1	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	5	3	4	5	.	3	5	7	6	3	2	2	1	2	5	7	2	3	.	.	.	.
.	.	.	.	.	.	.	.	.	3	4	2	3	7	6	4	6	4	4	2	5	3	5	6	6	9	7	6	1	.	.	.
.	.	.	.	.	.	.	.	6	8	7	5	4	5	4	3	3	4	4	5	8	8	7	5	5	1	4	4	5	3	.	.
.	.	.	.	.	.	1	2	6	3	3	6	5	6	2	2	2	5	6	5	5	6	3	1	2	6	6	7	4	5	2	.
.	.	.	.	.	1	3	5	7	4	5	6	6	3	.	.	.	.	.	2	3	4	7	5	4	3	1	2	5	2	3	.
.	.	.	.	.	3	4	3	2	7	8	3	.	.	.	.	.	.	.	.	1	4	7	7	6	3	1	3	7	8	9	.
.	.	.	.	2	6	4	.	4	4	2	.	.	.	.	.	.	.	.	.	.	.	1	4	3	6	5	2	3	1	5	.
1	1	.	3	4	3	2	3	4	1	1	.	.	.	.	.	.	.	.	.	.	.	.	3	4	6	8	6	1	4	7	.
2	1	5	7	4	1	4	6	4	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	5	7	8	6	.
7	6	4	.	3	3	6	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	6	5	6	.
8	2	2	3	2	4	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	2	4	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

SAMPLE NO. 94 RUN NO. 92

EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

```
1 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 1 . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 . . 1 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
1 1 1 1 1 . 1 . . . . . . . . . . . . . . . . . . . . . . . . .
1 . . . . . 1 1 1 . . . . . . . . . . . . . . . . . . . . . . .
1 . . 1 1 1 1 1 1 . . . . . . . . . . . . . . . . . . . . . . .
1 1 1 . . 1 . 1 . 1 . . . . . . . . . . . 1 . . . . . . . . . .
1 1 1 1 . . 1 1 1 1 . . . . . . . . 1 1 1 . 1 1 1 . . . . . . .
. . . 1 . . 1 1 . . 1 1 1 . . . . 1 1 1 1 1 1 1 1 1 1 . . . . .
. . 1 1 1 1 . 1 1 1 1 . 1 . . . 1 1 1 . . 1 1 1 . 1 1 . . . . .
. . . . 1 1 1 1 . . . 1 1 1 . 1 1 1 1 1 . . . 1 1 1 . 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 . . . .
. . . . . . . 1 . 1 . . 1 1 . 1 1 1 1 . 1 1 . . . 1 1 1 . . . .
. . . . . . 1 1 1 1 . . 1 1 1 . . 1 1 . . . . . . 1 1 1 1 . . .
. . . . . . . 1 1 1 1 1 . . 1 . . . . . . . . . 1 1 1 1 1 . . .
. . . . . . . . 1 1 1 1 . . . . . . . 1 1 1 1 1 1 1 1 . . . . .
. . . . . . . . . . . 1 1 . . . . . . 1 . 1 . 1 1 1 1 . . . . .
. . . . . . . . . 1 . 1 . . . . . . . . . 1 . 1 . . . . . . . .
. . . . . . . . . . 1 . 1 . 1 . . . . . . . . . 1 . . . . . . .
. . . . . . . . . . 1 . . 1 1 . 1 . . . 1 1 1 1 1 . . . . . . .
. . . . . . . . . . 1 . 1 1 . . 1 1 1 . . . . . 1 1 . . . . . .
. . . . . . . . . . 1 . . 1 1 1 1 1 1 . 1 . 1 1 1 1 1 1 . . . .
. . . . . . . . 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 1 1 . 1 1 1 . . .
. . . . . . . . 1 . . 1 1 1 . . . 1 1 1 1 1 . . . 1 1 1 1 1 . .
. . . . . . . 1 1 1 1 1 1 . . . . . . . . 1 1 1 1 . . . 1 . . .
. . . . . . 1 . . 1 1 . . . . . . . . . . 1 1 1 1 . . . 1 1 1 .
. . . . . 1 1 . 1 1 . . . . . . . . . . . . . 1 . 1 1 . . . 1 .
. . . . 1 . . . 1 . . . . . . . . . . . . . . . 1 1 1 1 . 1 1 .
. . 1 1 1 . 1 1 1 . . . . . . . . . . . . . . . . . 1 1 1 1 1 .
1 1 1 . . . 1 . . . . . . . . . . . . . . . . . . . . . 1 1 1 .
1 . . . . 1 . . . . . . . . . . . . . . . . . . . . . . 1 . 1 .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 94   RUN NO. 92

DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

```
. 1 . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . .
. 6 4 2 1 . . . . . . 1 . . . . . . . . . . . . . . . . . . . .
. 8 6 4 . 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
. 8 8 5 3 4 3 . . . . . . . . . . . . . . . . . . . . . . . . .
. Z Z 9 8 5 2 . . . . . . . . . . . . . . . . . . . . . . . . .
. 9 0 0 7 5 5 3 3 1 1 . . . . . . . . . . . . . . . . . . . . .
. 8 Z Z Z Z 0 7 5 3 1 . . . . . . . . . . . . . . 1 . . . . . .
. 6 8 9 Z Z 7 9 6 4 2 3 . . . . . . . . . 2 3 . 1 . 2 . . . . .
. 2 2 6 9 9 Z 3 9 6 6 2 1 . . . . . 1 4 7 6 3 5 4 2 1 . . . . .
. . 3 4 7 9 8 8 8 7 6 4 5 1 . 2 . 3 8 Z Z 9 8 8 8 6 4 . . . . .
. . . . 3 6 9 Z 3 3 Z 8 4 3 2 . . 3 4 8 Z K K 2 9 7 3 2 . . . .
. . . 1 2 4 8 9 Z Z Z Z 6 6 3 2 4 8 Z K S K Z K 8 6 3 5 . . . .
. . . . . 1 3 4 9 8 8 Z K Z 8 6 5 7 9 Z 3 S S K 3 Z 9 7 1 . . .
. . . . . . 1 3 7 9 Z Z Z 8 6 Z 9 8 K 3 Z 8 Z K S S 9 5 1 . . .
. . . . . . . . 5 8 9 Z 3 9 3 Z 8 9 8 Z Z Z 3 S K S 9 5 4 . . .
. . . . . . . 1 2 4 8 8 Z Z 9 9 8 8 8 Z Z S 3 3 S 8 6 1 . . . .
. . . . . . . . . 3 2 3 8 Z 0 Z 8 9 9 8 8 Z 7 8 Z 8 4 3 . . . .
. . . . . . . . . 1 4 3 7 8 0 0 Z 9 9 Z Z 8 7 8 3 1 . . . . . .
. . . . . . . . . . 1 3 4 6 8 0 0 0 0 Z 0 8 6 4 1 . . . . . . .
. . . . . . . . . . . 3 4 8 8 Z 8 Z Z 8 9 8 7 4 4 1 . . . . . .
. . . . . . . . . . . 3 5 4 7 8 9 Z Z Z Z Z Z 9 8 3 1 . . . . .
. . . . . . . . . . . 4 6 9 8 6 6 8 6 9 8 Z 0 0 8 6 . 3 . . . .
. . . . . . . . . . 3 4 6 4 3 3 3 3 6 8 8 Z K 3 Z 8 8 5 1 . . .
. . . . . . . . . 6 7 9 8 4 . 2 . 2 4 4 4 7 9 8 Z 8 7 5 4 3 . .
. . . . . . . 1 1 4 7 5 4 3 . . . . . . 2 3 6 0 0 Z 0 0 8 4 2 .
. . . . . . 1 3 6 8 8 3 . . . . . . . . . 1 3 6 8 9 9 8 8 4 3 1
. . . . . . 2 4 6 5 2 . . . . . . . . . . . . 1 3 6 9 0 Z 9 9 6
. . . . . 2 6 6 5 2 1 . . . . . . . . . . . . . 3 3 5 8 0 8 9 5
. 1 . . 3 3 4 5 3 1 1 . . . . . . . . . . . . . . . . 4 7 9 Z 0
. 1 2 4 7 5 5 . . . . . . . . . . . . . . . . . . . . 2 2 6 5 9
. 6 5 6 4 3 2 . 2 . . . . . . . . . . . . . . . . . . . . 1 3 7
. 7 8 7 5 3 . . . . . . . . . . . . . . . . . . . . . . . 3 4 6
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SAMPLE NO. 94   RUN NO. 92

CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. 1 2 . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . 8 8 . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . 2 1 2 2 8 . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . 2 3 . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . 8 . . . . . . . . . . . . 1 2 . . . . . . . . . . .
. . . . . . . 2 3 3 1 . . . . . . . . 8 2 4 4 2 . . . . . . . .
. . . . . . . . 1 1 1 2 . . . . . . 1 4 5 4 1 4 8 . . . . . . .
. . . . . . . . . . . 2 4 1 . . . . . 1 3 5 5 4 3 2 . . . . . .
. . . . . . . . . . 2 1 2 . . 1 . 8 4 3 2 8 2 4 5 5 . . . . . .
. . . . . . . . . . . 2 3 . 3 1 8 . 8 1 1 2 3 5 4 5 . . . . . .
. . . . . . . . . . . . 2 1 . . . . . 1 1 5 3 3 5 . . . . . . .
. . . . . . . . . . . . . 2 8 1 . . . . 1 . . 1 . . . . . . . .
. . . . . . . . . . . . . . 8 8 1 . . 1 1 8 . . . . . . . . . .
. . . . . . . . . . . . . . . 8 8 8 8 1 8 . . . . . . . . . . .
. . . . . . . . . . . . . . . 1 . 2 2 8 . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 1 2 1 2 2 1 . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . 8 2 8 8 . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . 2 4 3 2 . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . 1 . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . 8 8 2 8 8 . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . 8 1 . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . 8 . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2 8
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 94      RUN NO.  92

CORRELATION REFERENCE MATRIX

  0  0  0  0  7  714141412  9  3  2  0  0  0
  4  0  0  11324242117181611  6  0  0  0
  8  3  2  61117252625232112  9  2  0  0
 12  71415192630272522181110  8  2  0
2017171316262728273025262016  7  1
182023222425232528303126141 1  2  0
2022171817192324283030271816  6  0
221815171619222326252418  6  0  0  0
20172117161818161217171 3  8  1  0  0
151617151419171613  8  1  0  0  0  0  0
13171921242025211 6  9  4  1  0  0  0  0
16161718222320211714  9  3  2  0  0  0
13131415192223242321 1412  6  1  0  0
15121111131723242519171612  7  1  0
  8  5  2  3  81218232223232119 13  8  1
  4  0  1  1  6  8  91518181921171512  5

TRACKING ERRORS

EDGE ERRORS XM=   .5410   YM=  -.2667      XC= -3.8965   YC= -1.5792

CENTROID ERRORS XM=  3.4731   YM= -1.1998     XC=  -.9644   YC= -2.5123

CORRELATION ERRORS XM=  5.8686   YM=   .1645     XC=  1.4311   YC= -1.1480

FRAME OFFSETS    4    1     INPUT INCR. ERRORS         .4375       .3125

 FINAL SEARCH CORRELATIONS -
1.13E+03   9.12E+02   1.34E+03   8.10E+02   4.30E+02   8.42E+02   1.14E+03   6.94E+02   9.60E+02
```

STATISTICAL DATA

		RESOLUTION ELEMENTS			REGRESSION COEF	
CENTFOID - X AXIS	MEAN	1.487672E+00	RMS	4.702611E-01	BETA	2.697525E-02
CENTROID - Y AXIS	MEAN	-1.081910E+00	RMS	4.155664E-01	BETA	-2.377611E-02
RADIAL ERROR(RMS)=	.6276	DRIFT DISTANCE=	3.3800			
DIG CORR - X AXIS	MEAN	1.051763E+00	RMS	3.565133E-01	BETA	2.286205E-02
DIG CORR - Y AXIS	MEAN	-1.246451E-01	RMS	3.307124E-01	BETA	-7.242536E-03
RADIAL ERROR(RMS)=	.4863	DRIFT DISTANCE=	2.2543			
EDGE - X AXIS	MEAN	1.376492E+01	RMS	8.786148E+00	BETA	1.636735E-01
EDGE - Y AXIS	MEAN	-3.676559E-01	RMS	1.419098E+00	BETA	-2.145061E-02
PADIAL ERROR(RMS)=	8.9000	DRIFT DISTANCE=	15.5169			

TRACKING ERRORS

CENTROID - X AXIS

1.3139	.4387	.6246	.4657	.0550	.6539	-.1836	1.2184	.0432	.0253
1.3553	.3787	1.1723	.4188	1.3431	.2789	1.3734	1.0874	1.2256	.0867
.7481	.7418	.5452	2.1366	.2775	-.0432	.8896	.0540	.7766	.5301
.8628	.9047	1.1115	.6174	.9709	1.7209	.9116	-.7250	.6570	1.6244
1.2330	1.3475	2.1550	1.1755	2.4521	2.7848	1.4944	1.8120	.3766	2.1573
1.6937	.9895	.6023	1.6738	2.0500	2.4843	2.5654	2.0275	2.3104	.7081
1.2032	.7593	1.9605	2.0446	2.8887	1.7537	2.2944	2.3047	2.3955	2.3036
2.9245	2.2757	1.8576	1.8236	.6125	1.8978	2.1927	2.3230	2.4001	2.8609
2.5059	3.2264	1.2601	2.9751	2.6595	3.2795	3.4230	2.0698	3.4244	2.4851
2.9834	1.9780	1.9300	1.8121						

CENTPOID - Y AXIS

-.0395	.2226	.0334	-.1395	.0403	.1292	-.5197	-.1006	-.4779	-.5969
-.0368	-.3923	.0362	-.0874	-.3580	-.8165	.4816	.2628	.2611	-.3417
-.0890	-.8208	-.8808	.0375	-1.4885	.0893	-.8756	-.0134	-1.0320	-1.1285
.0554	-.5257	-.7471	-.7196	-.7891	-.6868	-.7689	-.3562	-1.1564	-1.6755
-.3972	-1.7017	-1.5000	-1.6597	-1.3732	-2.0575	-1.3849	-1.3606	-.7144	-1.9613
-1.7358	-.6965	-.8051	-2.3996	-1.2690	-1.2341	-1.4060	-.7155	-.5892	-.5128
-2.7053	-1.8960	-1.1822	-1.6986	-1.0762	-.6547	-1.2654	-1.2369	-1.3799	-1.5366
-.7177	-1.1225	-3.0110	-2.3363	-1.7781	-2.1409	-1.0523	-1.9057	-.9111	-1.6288
-.7355	-2.1579	-2.8502	-1.4567	-2.7597	-2.5026	-1.9001	-2.3947	.6639	-2.6775
-2.2917	-2.3410	-3.1124	-2.8125						

OIG CORR - X AXIS

.1082	.0270	-.3953	.2425	-.0806	.2066	-.1463	-.0266	-.1084	.2761
.3105	.3124	.3554	.3897	.7997	.4494	.5522	.0312	-.0895	-.0572
.1489	.5856	-.3095	.4920	-.1527	.5188	-.0765	.3701	-.1742	.4813
.1023	.7486	.4000	1.1931	.2166	.7212	.2308	.6705	.5057	1.1023
1.1897	1.2715	1.2461	1.2896	1.5962	1.5184	1.7237	1.4818	1.4228	1.4686
1.4400	1.6543	1.6761	1.9493	1.6747	1.7609	1.7387	1.4560	1.7733	1.5046
1.9738	1.9417	1.9866	2.0102	2.0051	1.8840	1.8917	1.8380	1.5195	1.7355
1.5101	1.8059	1.3341	1.5504	1.3809	1.6410	1.6984	1.8565	1.5871	2.1060
1.6791	1.6636	1.3993	1.4803	1.3423	1.4570	1.3546	1.5493	1.6293	1.5868
1.6368	1.7198	1.6767	1.4311						

OIG CORR - Y AXIS

.0226	-.0108	.0023	.0004	.0025	.0733	-.0461	-.0552	-.1825	-.0992
-.2024	-.0907	-.1034	-.0275	-.0257	-.0363	-.0416	-.0462	-.1066	-.1733
-.1422	-.2361	-.2116	-.3485	-.2331	-.3749	.0857	-.3064	.2069	.0387
.3483	.0878	.2925	.0237	.2140	-.1379	.1250	-.1121	.0868	.0538
.1659	.2358	.1971	.2971	1499	.1401	.0727	.1769	.0364	.2221
-.0094	.2032	.1127	.2145	.1049	.1726	.1158	.1845	.4442	.2433
.4465	.4874	.3266	.2105	.1437	.1505	.0627	.0671	.0035	.0130
-.0303	-.0945	-.1542	-.2392	-.3024	-.3305	-.3846	-.4647	-.4236	-.5765
-.4970	-.6335	-.7695	-.7321	-.8044	-.7773	-.8932	-.8945	-.9768	-1.1771
-1.2216	-1.0851	-1.2786	-1.1430						

TRACKING ERRORS (Continued)

EDGE - X AXIS

-.9248	3.4102	-2.9190	-3.9903	2.9491	13.1408	6.5838	8.7152	5.5382	10.9419
15.1572	9.2772	29.8044	6.6974	20.6069	12.1555	-1.6186	4.7277	21.7234	11.8794
8.1987	7.0904	9.2350	16.0913	28.8738	-.5221	13.9286	8.3136	20.4954	13.6886
6.5978	8.8787	15.9932	6.2040	6.4404	13.0366	16.2592	-3.8322	16.0031	9.0546
9.5225	-5.6216	6.3120	-1.2216	26.0562	2.1048	20.1215	28.1100	-7.4469	7.2939
22.2343	5.3595	-7.4158	1.4137	17.9967	23.4865	33.6696	17.9086	13.0193	1.5097
1.0440	9.7643	16.8882	22.2473	26.6443	1.5527	19.5707	32.1025	41.2274	22.2391
53.6201	52.1958	3.3063	-.6609	17.0271	22.5028	10.3557	23.1195	9.4869	23.8102
21.5304	30.5294	20.1475	42.8126	25.9223	21.3943	6.2965	13.1700	21.1615	17.7376
20.2781	16.5201	1.5129	4.3578						

EDGE - Y AXIS

-.8460	.2972	.6558	-.5879	-1.7237	-.9518	-3.5488	2.5766	-2.2316	-2.0977
4.1853	3.7131	3.6704	-.6675	1.6623	-1.4468	5.8721	3.8324	3.9655	-.8340
3.2102	-1.7186	-2.5766	2.9762	-2.8881	3.4221	-4.3599	1.7820	-3.2215	-3.6649
1.3160	-.3658	-2.6758	.8460	-2.7184	.6988	-.6895	.9977	-.2770	-1.0239
1.1517	.7070	-2.3052	1.3304	-1.4660	-.0561	.7345	2.3477	-.3746	-.0164
-.0240	.6897	-1.1453	-1.7354	-2.3207	-.2875	-.8096	-1.5674	-1.1314	1.5932
1.5481	-1.1333	-2.7471	-3.8098	-1.8709	.0883	-1.7955	1.5920	.2254	-1.5832
1.4483	.9965	.6153	1.2767	-3.4849	-2.6250	-.2030	-4.2111	-1.7764	-3.2543
.6990	.6606	-4.7186	.1792	-1.3858	-4.3026	2.0230	-3.8419	4.1109	-2.0658
-.5478	-4.0374	.9937	-2.1300						

FILTERED TRACKER DATA

CENTROID - X AXIS

0.0000	0.0000	.5599	.7137	.4274	.3140	.1472	.4782	.5437	.3189
.5136	.7033	.9467	.8098	.9061	.7554	.8873	1.0622	1.2365	.8300
.5013	.4946	.6213	1.2395	1.2412	.5979	.2579	.2068	.4627	.6071
.7558	.8613	1.0056	.9219	.8508	1.1612	1.3067	.5222	.0004	.5333
1.3191	1.6139	1.7865	1.6547	1.8480	2.3509	2.3345	1.9480	1.1100	1.1161
1.5370	1.6057	1.0766	.9751	1.5032	2.2422	2.6578	2.5039	2.2471	1.5578
1.0504	.7629	1.1880	1.8233	2.5302	2.5052	2.2515	2.1263	2.2642	2.3702
2.6023	2.6063	2.2704	1.8658	1.2361	1.1802	1.9066	2.5596	2.6882	2.6563
2.6106	2.8369	2.3753	2.2465	2.4311	2.9646	3.3677	3.0097	2.8324	2.7021
2.8077	2.5300	2.1109	1.7828						

CENTROID - Y AXIS

0.0000	0.0000	.0724	.0261	-.0316	.0159	-.1364	-.2477	-.3695	-.4903
-.3867	-.2820	-.1214	-.0476	-.1411	-.4870	-.3105	.1271	.4174	.1560
-.1566	-.5234	-.8076	-.6031	-.7258	-.5674	-.5739	-.3531	-.5153	-.8831
-.7414	-.4337	-.4057	-.6342	-.8121	-.8037	-.7511	-.5780	-.7040	-1.2004
-1.1931	-1.2222	-1.3586	-1.6115	-1.6033	-1.7151	-1.6769	-1.5128	-1.0884	-1.2097
-1.6003	-1.4783	-.9875	-1.2669	-1.6269	-1.6056	-1.3637	-1.0275	-.7101	-.4930
-1.2869	-2.0908	-2.0462	-1.6225	-1.2287	-.9001	-.8830	-1.0916	-1.3403	-1.4957
-1.2452	-1.0016	-1.6830	-2.4707	-2.5102	-2.1418	-1.5471	-1.4256	-1.2741	-1.3446
-1.1552	-1.4214	-2.1742	-2.3491	-2.3764	-2.4121	-2.3054	-2.2135	-1.0881	-.9943
-1.7114	-2.5055	-2.9258	-2.9933						

DIG CORR - X AXIS

0.0000	0.0000	-.1276	-.0849	-.0180	.1102	.0556	-.0315	-.1056	.0263
.2332	.3622	.3809	.3731	.5361	.6138	.5953	.3391	.0295	-.1427
-.0561	.2788	.2374	.2113	.0694	.1902	.1751	.2210	.0855	.1567
.2068	.4405	.5448	.8154	.7274	.6135	.4022	.4301	.5099	.7858
1.0854	1.2906	1.3223	1.2907	1.3902	1.5186	1.6517	1.6331	1.5151	1.4256
1.4132	1.5173	1.6421	1.8135	1.8379	1.7850	1.7263	1.6117	1.6079	1.5934
1.7344	1.8979	2.0109	2.0314	2.0154	1.9559	1.8974	1.8513	1.7107	1.6353
1.5745	1.6472	1.5784	1.5060	1.4216	1.4841	1.6181	1.7815	1.7719	1.8547
1.8500	1.7643	1.5537	1.4254	1.3627	1.3889	1.3978	1.4548	1.5539	1.6214
1.6410	1.6686	1.6914	1.5993						

DIG CORR - Y AXIS

0.0000	0.0000	.0010	-.0003	.0009	.0294	.0190	-.0241	-.1116	-.1489
-.1723	-.1470	-.1134	-.0629	-.0272	-.0182	-.0305	-.0448	-.0732	-.1270
-.1616	-.1978	-.2184	-.2757	-.2907	-.3195	-.1777	-.1307	-.0056	.0719
.2138	.2272	.2335	.1513	.1308	.0298	.0099	-.0313	-.0008	.0399
.1132	.1919	.2296	.2595	.2295	.1716	.1018	.1041	.0957	.1357
.1045	.1155	.1256	.1706	.1650	.1556	.1348	.1468	.2713	.3406
.3910	.4396	.4277	.3196	.1848	.1180	.0876	.0714	.0374	.0110
-.0142	-.0542	-.1143	-.1912	-.2684	-.3239	-.3646	-.4175	-.4467	-.5021
-.5292	-.5757	-.6710	-.7499	-.7950	-.7969	-.8298	-.8766	-.9384	-1.0555
-1.1827	-1.1988	-1.2047	-1.1892						

FILTERED TRACKER DATA (Continued)

EDGE - X AXIS

0.0000	0.0000	-.2517	-2.0161	-1.4205	5.2633	9.9944	10.5562	7.7030	7.4947
11.0849	12.7764	19.1870	18.2325	17.1245	14.3475	7.5695	2.1713	8.0371	15.0184
14.8161	9.4177	6.6684	10.1659	20.1111	17.5446	11.6468	7.2762	12.1428	16.2664
13.8138	8.9613	9.6503	10.3121	8.6764	8.7775	12.5854	8.7255	7.6264	8.5882
10.4902	4.4673	.9220	-.4664	9.9909	13.5710	15.7429	20.5028	13.5808	4.7917
7.4575	11.8663	5.5720	-1.9841	3.3263	16.8621	29.9670	29.9030	20.4452	7.4586
-.3051	1.5975	10.4102	19.7182	25.8340	18.3095	12.5567	18.5554	33.3828	36.2249
40.4679	47.5856	35.2622	18.4486	.3062	10.1580	18.1794	21.1071	16.6633	16.7399
19.6161	25.9385	26.5539	31.6870	32.7885	28.2451	15.9597	8.7136	11.9969	18.1638
21.3630	19.7377	11.3460	3.7132						

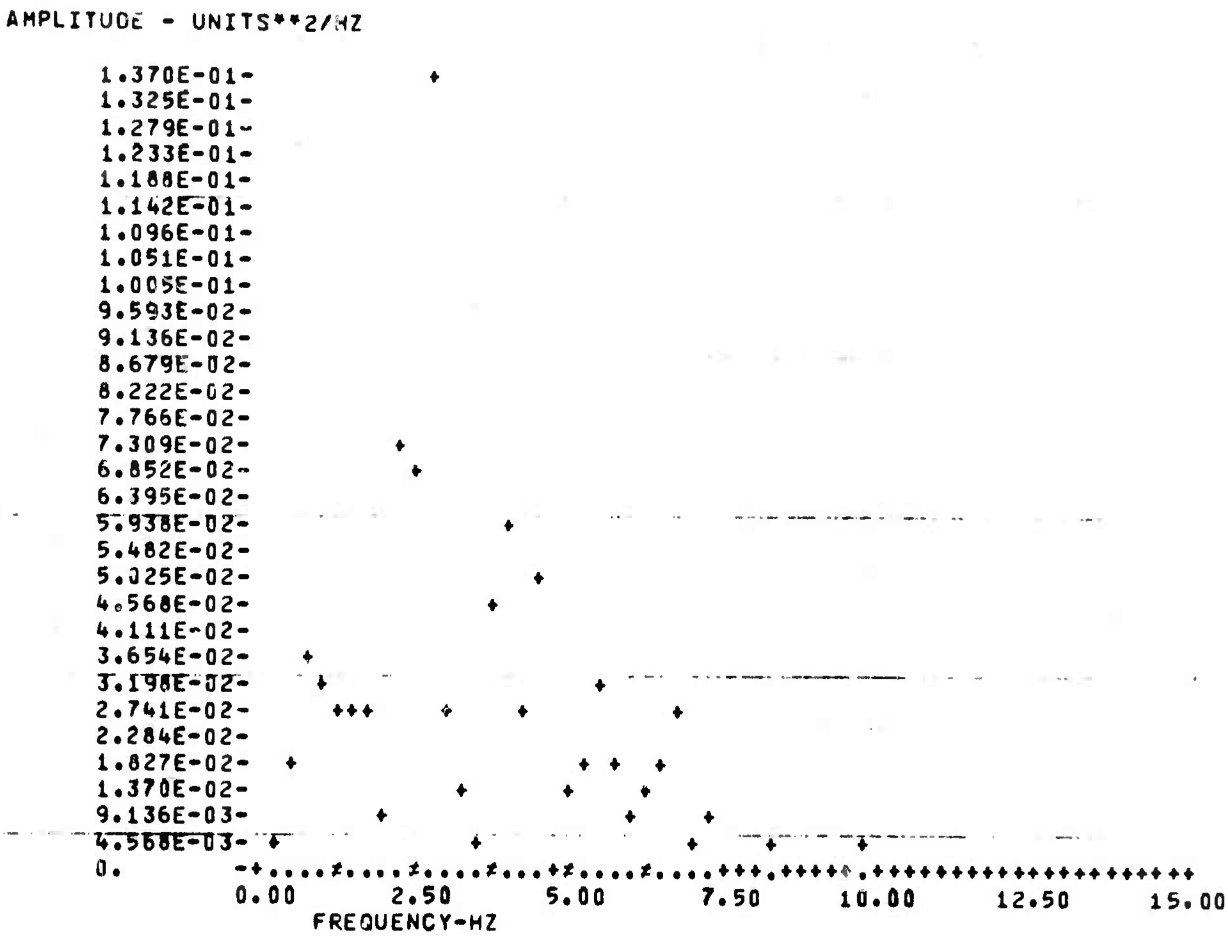
EDGE - Y AXIS

0.0000	0.0000	.2148	.1213	-.7468	-1.3812	-2.3488	-.9368	-.3072	-.9244
.2869	2.8040	4.4515	2.7089	.8705	-.6282	1.4505	3.9374	5.0375	2.6688
1.2395	-.0990	-1.4905	-.6009	-.4156	.8860	-.4913	-.6486	-1.5154	-2.6496
-1.8946	-.3710	-.4925	-.6433	-1.3484	-.8835	-.4562	.3447	.4170	-.2294
-.1584	.4551	-.2195	-.3302	-.6034	-.4565	.0191	1.2700	1.2996	.4673
-.2662	-.0396	-.1703	-.9742	-2.0090	-1.7498	-.9566	-.7824	-1.0918	-.2490
1.1349	.9207	-1.0673	-3.2898	-3.5683	-1.7989	-.6552	.3627	.6995	-.0700
-.1489	.5225	1.0585	1.1834	-.6178	-2.5580	-2.4647	-2.4614	-2.3817	-2.7786
-1.5738	.1093	-.9246	-1.7324	-1.7468	-2.3429	-1.3074	-1.3890	.4679	.5629
-.0838	-2.2413	-2.0090	-1.3919						

SPECTRAL DENSITY CENTROID - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	3.84277E-03	7.75000E+00	1.32017E-03
5.00000E-01	1.70081E-02	8.00000E+00	1.34504E-03
7.50000E-01	3.45142E-02	8.25000E+00	3.87417E-03
1.00000E+00	3.10532E-02	8.50000E+00	2.76123E-04
1.25000E+00	2.53057E-02	8.75000E+00	1.61826E-03
1.50000E+00	2.62092E-02	9.00000E+00	3.94613E-04
1.75000E+00	2.51937E-02	9.25000E+00	2.48674E-04
2.00000E+00	1.05268E-02	9.50000E+00	7.22859E-04
2.25000E+00	7.38195E-02	9.75000E+00	3.18132E-03
2.50000E+00	6.84869E-02	1.00000E+01	2.06957E-04
2.75000E+00	1.37040E-01	1.02500E+01	7.38487E-04
3.00000E+00	2.87543E-02	1.05000E+01	3.12684E-04
3.25000E+00	1.22380E-02	1.07500E+01	5.02425E-04
3.50000E+00	6.16398E-03	1.10000E+01	1.29135E-03
3.75000E+00	4.74902E-02	1.12500E+01	9.99051E-05
4.00000E+00	5.76812E-02	1.15000E+01	2.14152E-03
4.25000E+00	2.87957E-02	1.17500E+01	6.24868E-04
4.50000E+00	4.80522E-02	1.20000E+01	5.46920E-05
4.75000E+00	1.95543E-03	1.22500E+01	6.38020E-05
5.00000E+00	1.57285E-02	1.25000E+01	1.01500E-04
5.25000E+00	1.72431E-02	1.27500E+01	6.27536E-04
5.50000E+00	3.33103E-02	1.30000E+01	7.56183E-04
5.75000E+00	1.70596E-02	1.32500E+01	1.94488E-04
6.00000E+00	8.47602E-03	1.35000E+01	6.74337E-04
6.25000E+00	1.47116E-02	1.37500E+01	1.08703E-03
6.50000E+00	2.04240E-02	1.40000E+01	1.51427E-03
6.75000E+00	2.64126E-02	1.42500E+01	1.10843E-03
7.00000E+00	3.36637E-03	1.45000E+01	1.53446E-04
7.25000E+00	8.71409E-03	1.47500E+01	6.51680E-05
7.50000E+00	1.79357E-03	1.50000E+01	9.41010E-04

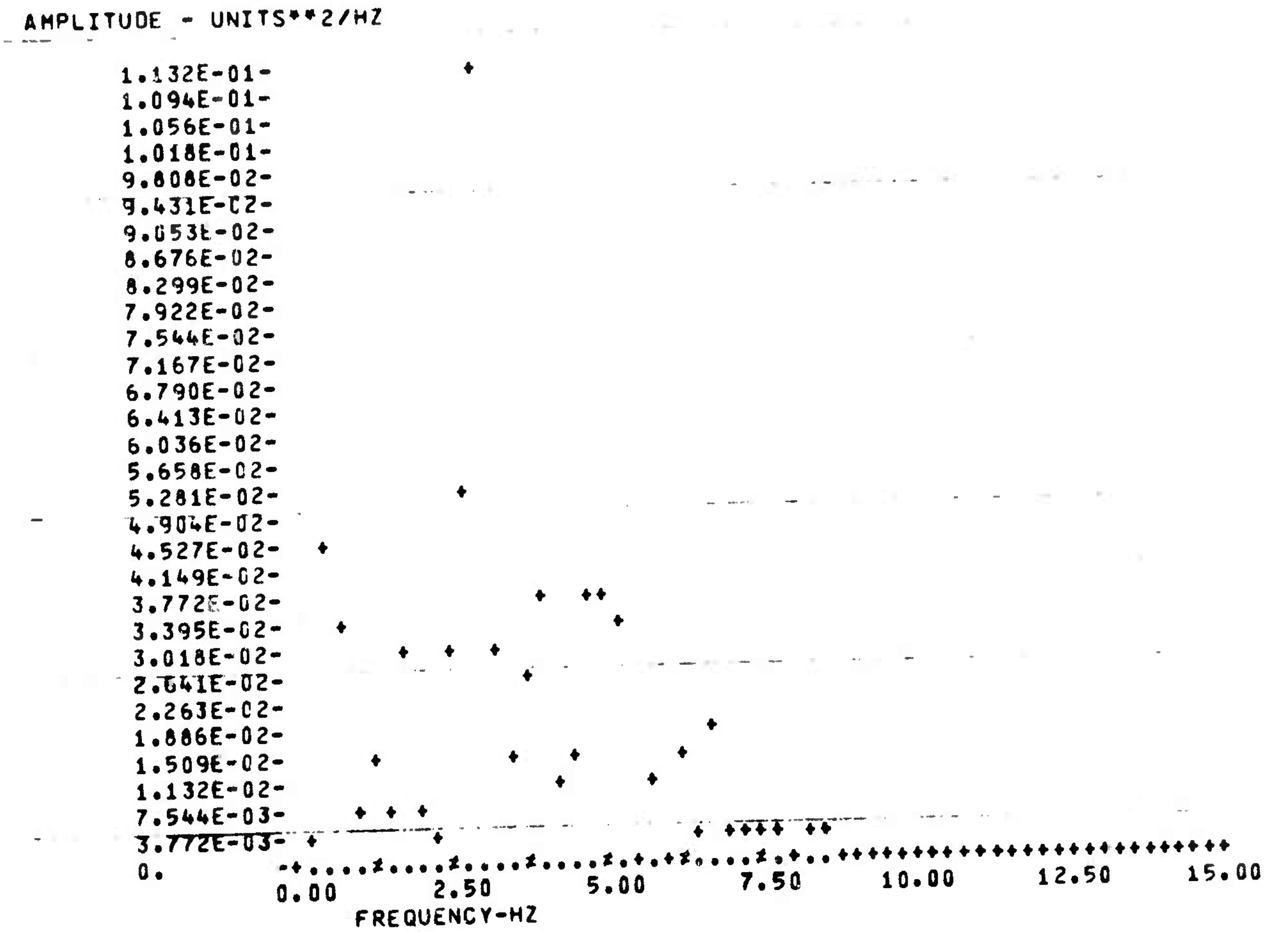
SPECTRAL DENSITY CENTROID - X AXIS



SPECTRAL DENSITY CENTROID - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	3.96410E-03	7.75000E+00	2.16015E-03
5.00000E-01	4.54238E-02	8.00000E+00	1.74743E-03
7.50000E-01	3.38442E-02	8.25000E+00	4.22871E-03
1.00000E+00	6.96342E-03	8.50000E+00	5.45198E-03
1.25000E+00	1.33255E-02	8.75000E+00	6.69462E-04
1.50000E+00	8.59374E-03	9.00000E+00	1.64670E-03
1.75000E+00	2.92990E-02	9.25000E+00	7.69757E-04
2.00000E+00	9.41616E-03	9.50000E+00	7.51441E-04
2.25000E+00	3.23387E-03	9.75000E+00	3.23115E-05
2.50000E+00	3.10131E-02	1.00000E+01	1.52718E-03
2.75000E+00	5.25597E-02	1.02500E+01	2.86328E-04
3.00000E+00	1.13167E-01	1.05000E+01	1.67878E-03
3.25000E+00	3.07124E-02	1.07500E+01	6.06112E-04
3.50000E+00	1.46250E-02	1.10000E+01	2.73560E-04
3.75000E+00	2.45923E-02	1.12500E+01	1.10131E-03
4.00000E+00	3.90768E-02	1.15000E+01	1.03415E-03
4.25000E+00	1.04372E-02	1.17500E+01	6.95809E-04
4.50000E+00	1.45467E-02	1.20000E+01	2.18619E-04
4.75000E+00	3.87809E-02	1.22500E+01	6.59842E-04
5.00000E+00	3.76848E-02	1.25000E+01	7.31729E-04
5.25000E+00	3.44877E-02	1.27500E+01	5.32671E-05
5.50000E+00	1.11933E-03	1.30000E+01	5.62827E-04
5.75000E+00	1.11318E-02	1.32500E+01	3.10762E-06
6.00000E+00	1.62400E-03	1.35000E+01	4.98866E-04
6.25000E+00	1.45567E-02	1.37500E+01	2.85605E-04
6.50000E+00	3.71576E-03	1.40000E+01	1.65298E-04
6.75000E+00	1.71105E-02	1.42500E+01	1.07654E-03
7.00000E+00	2.10734E-03	1.45000E+01	3.33597E-04
7.25000E+00	4.08806E-03	1.47500E+01	4.42874E-04
7.50000E+00	2.14698E-03	1.50000E+01	8.87811E-04

SPECTRAL DENSITY CENTROID - Y AXIS

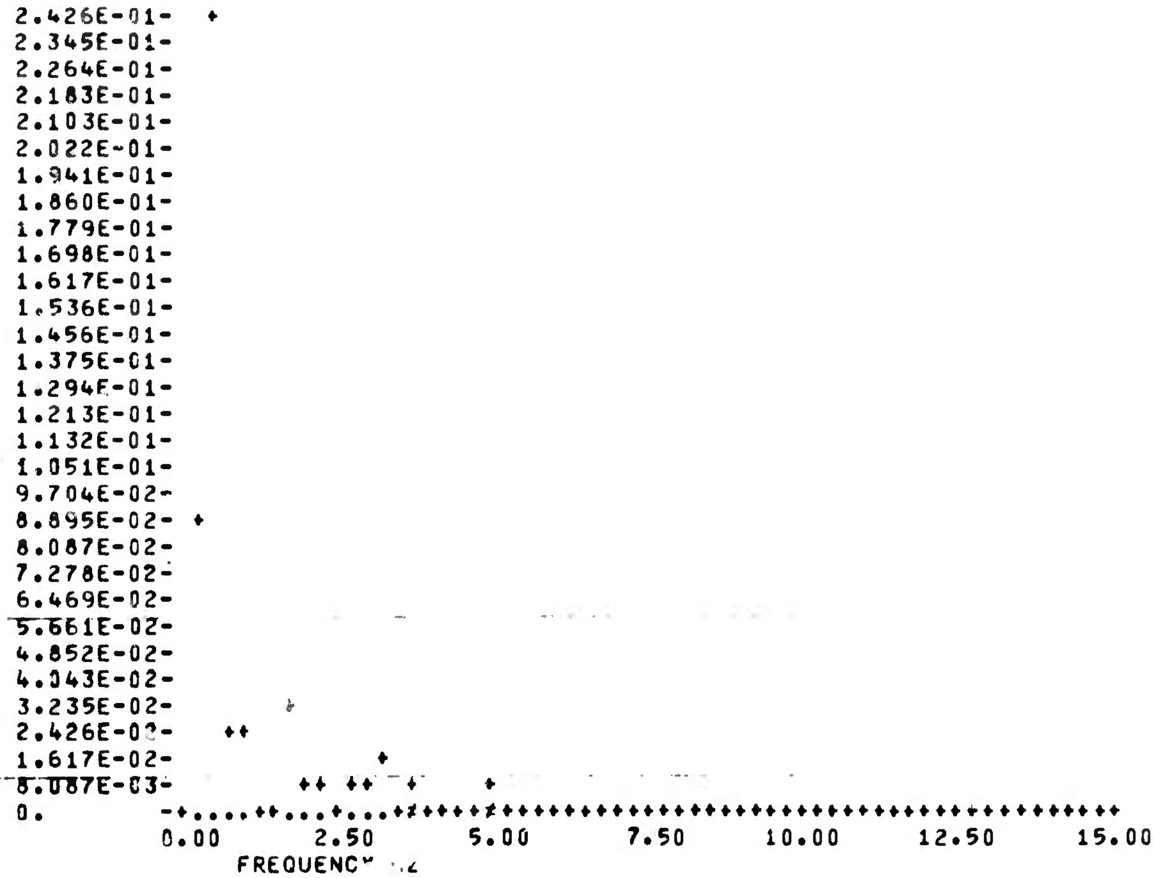


SPECTRAL DENSITY DIG CORR - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	9.29294E-02	7.75000E+00	2.87890E-04
5.00000E-01	2.42602E-01	8.00000E+00	6.45832E-05
7.50000E-01	2.29218E-02	8.25000E+00	2.13904E-04
1.00000E+00	2.67541E-02	8.50000E+00	6.73565E-05
1.25000E+00	7.34348E-04	8.75000E+00	6.19836E-05
1.50000E+00	3.70701E-03	9.00000E+00	2.90589E-04
1.75000E+00	3.07686E-02	9.25000E+00	7.03931E-05
2.00000E+00	5.50976E-03	9.50000E+00	5.42227E-05
2.25000E+00	7.29400E-03	9.75000E+00	9.96939E-05
2.50000E+00	1.86231E-03	1.00000E+01	9.02304E-05
2.75000E+00	1.04690E-02	1.02500E+01	2.26007E-04
3.00000E+00	8.11484E-03	1.05000E+01	6.13563E-05
3.25000E+00	1.33953E-02	1.07500E+01	8.87096E-05
3.50000E+00	1.37078E-04	1.10000E+01	8.15805E-05
3.75000E+00	9.33783E-03	1.12500E+01	3.33136E-05
4.00000E+00	9.08127E-04	1.15000E+01	9.05461E-05
4.25000E+00	1.81361E-03	1.17500E+01	1.25393E-04
4.50000E+00	2.72715E-03	1.20000E+01	7.09812E-05
4.75000E+00	2.58424E-03	1.22500E+01	1.03415E-04
5.00000E+00	4.16072E-03	1.25000E+01	4.[illegible]3768E-05
5.25000E+00	2.79520E-03	1.27500E+01	1.28442E-04
5.50000E+00	7.72650E-04	1.30000E+01	1.09266E-04
5.75000E+00	2.14973E-03	1.32500E+01	1.40735E-04
6.00000E+00	2.64042E-03	1.35000E+01	1.40972E-04
6.25000E+00	1.18991E-06	1.37500E+01	2.52976E-04
6.50000E+00	8.80362E-04	1.40000E+01	4.81610E-05
6.75000E+00	2.86199E-04	1.42500E+01	5.80604E-04
7.00000E+00	1.89208E-04	1.45000E+01	1.68918E-04
7.25000E+00	1.25148E-04	1.47500E+01	3.86295E-04
7.50000E+00	1.27970E-04	1.50000E+01	2.77295E-04

SPECTRAL DENSITY DIG CORR - X AXIS

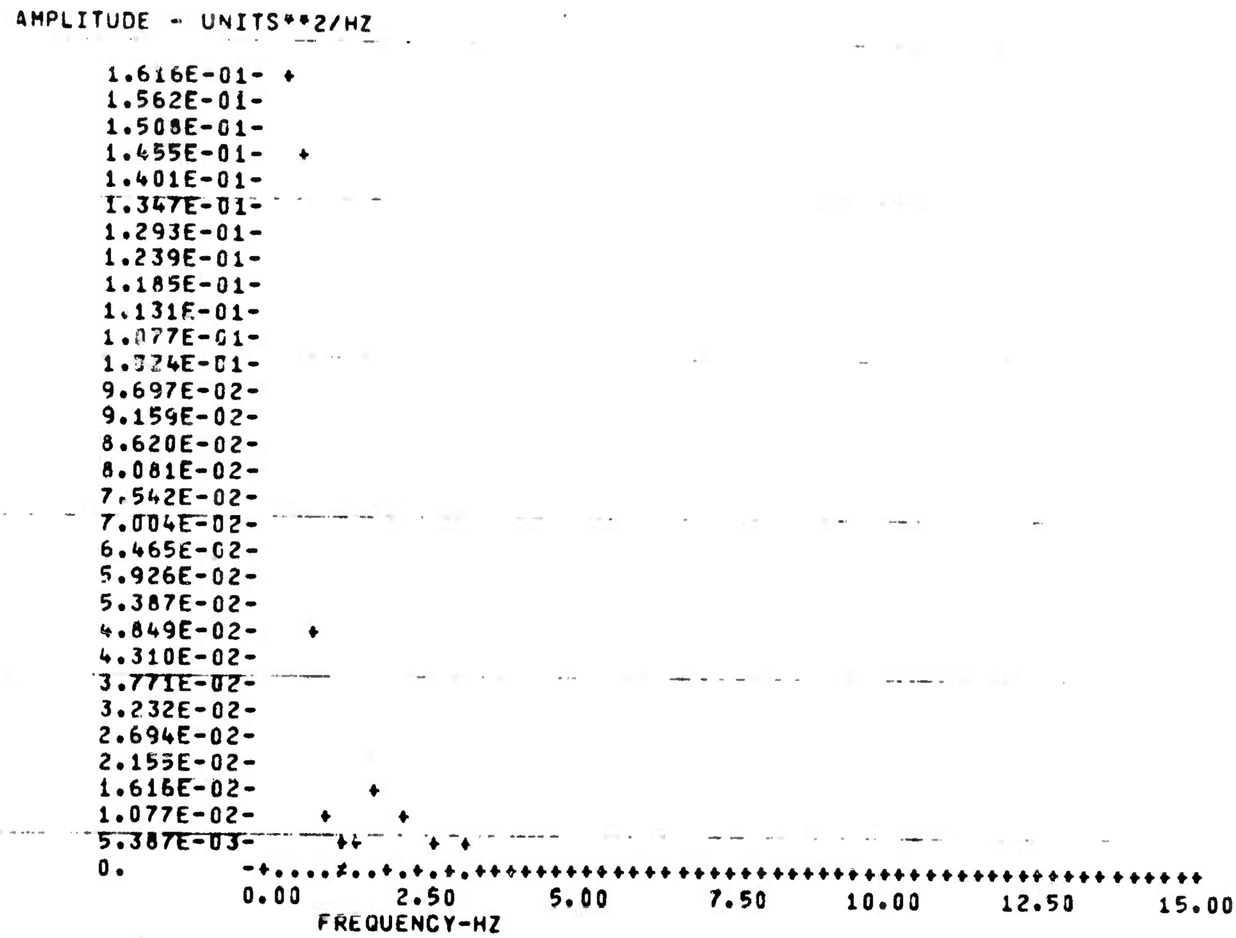
AMPLITUDE - UNITS**2/HZ



SPECTRAL DENSITY DIG CORR - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.61622E-01	7.75000E+00	1.07989E-04
5.00000E-01	1.43797E-01	8.00000E+00	4.10728E-05
7.50000E-01	5.02378E-02	8.25000E+00	1.07132E-04
1.00000E+00	1.26177E-02	8.50000E+00	3.17050E-04
1.25000E+00	2.69720E-03	8.75000E+00	2.06912E-04
1.50000E+00	7.33837E-03	9.00000E+00	1.55615E-04
1.75000E+00	1.56853E-02	9.25000E+00	1.45246E-04
2.00000E+00	7.21288E-04	9.50000E+00	1.74097E-04
2.25000E+00	1.29389E-02	9.75000E+00	2.26749E-04
2.50000E+00	1.23112E-04	1.00000E+01	2.24508E-04
2.75000E+00	7.21613E-03	1.02500E+01	9.46893E-05
3.00000E+00	7.25542E-05	1.05000E+01	6.19478E-05
3.25000E+00	5.59077E-03	1.07500E+01	1.80111E-04
3.50000E+00	1.23890E-03	1.10000E+01	2.55913E-04
3.75000E+00	2.37850E-03	1.12500E+01	1.08773E-04
4.00000E+00	1.40227E-03	1.15000E+01	8.34343E-05
4.25000E+00	6.69263E-04	1.17500E+01	8.45760E-05
4.50000E+00	8.00792E-04	1.20000E+01	1.72669E-04
4.75000E+00	4.33043E-04	1.22500E+01	1.20135E-04
5.00000E+00	3.34680E-04	1.25000E+01	8.35889E-05
5.25000E+00	5.83808E-04	1.27500E+01	6.18497E-05
5.50000E+00	8.97645E-05	1.30000E+01	7.67456E-05
5.75000E+00	1.91439E-04	1.32500E+01	2.04033E-04
6.00000E+00	9.30796E-05	1.35000E+01	1.38411E-04
6.25000E+00	2.51571E-04	1.37500E+01	1.97813E-05
6.50000E+00	6.90241E-04	1.40000E+01	1.27789E-04
6.75000E+00	1.64089E-04	1.42500E+01	9.87162E-05
7.00000E+00	5.46170E-05	1.45000E+01	3.54553E-04
7.25000E+00	1.11917E-04	1.47500E+01	1.13117E-05
7.50000E+00	4.60639E-04	1.50000E+01	1.08837E-04

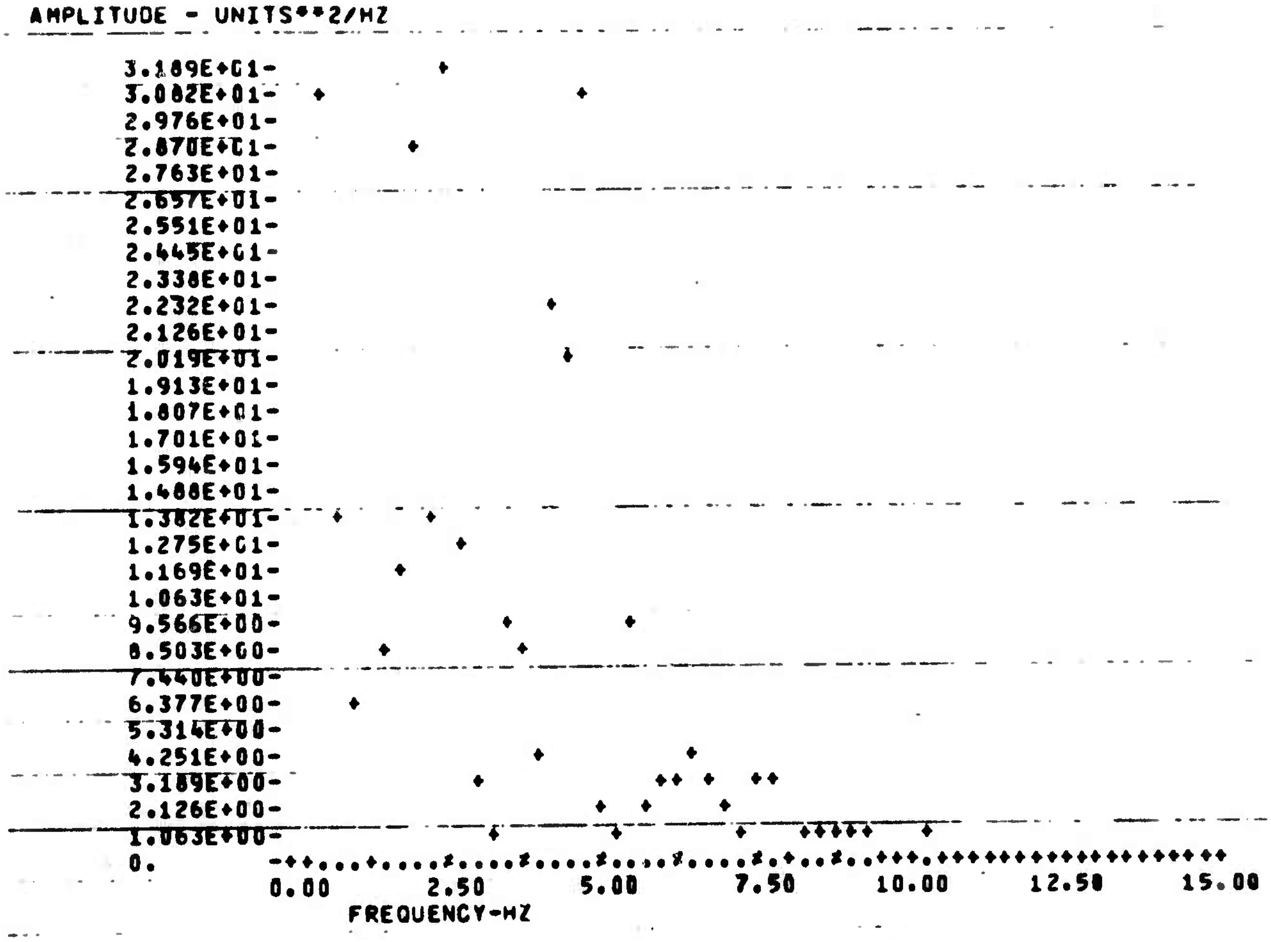
SPECTRAL DENSITY DIG CORR - Y AXIS



SPECTRAL DENSITY EDGE - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	5.16479E-01	7.75000E+00	3.27091E+00
5.00000E-01	3.06492E+01	8.00000E+00	3.61091E-03
7.50000E-01	1.40981E+01	8.25000E+00	6.97920E-01
1.00000E+00	6.68033E+00	8.50000E+00	5.77070E-01
1.25000E+00	3.64858E-01	8.75000E+00	1.38512E+00
1.50000E+00	8.64334E+00	9.00000E+00	1.16754E+00
1.75000E+00	1.16956E+01	9.25000E+00	5.37678E-01
2.00000E+00	2.90466E+01	9.50000E+00	3.31078E-01
2.25000E+00	1.37330E+01	9.75000E+00	9.57302E-02
2.50000E+00	3.18850E+01	1.00000E+01	4.11388E-02
2.75000E+00	1.28413E+01	1.02500E+01	8.17152E-01
3.00000E+00	3.04537E+00	1.05000E+01	2.79483E-02
3.25000E+00	7.17746E-01	1.07500E+01	2.99944E-01
3.50000E+00	1.00083E+01	1.10000E+01	3.04108E-01
3.75000E+00	8.35310E+00	1.12500E+01	2.48644E-02
4.00000E+00	4.67427E+00	1.15000E+01	1.27714E-01
4.25000E+00	2.21212E+01	1.17500E+01	7.20081E-02
4.50000E+00	2.06177E+01	1.20000E+01	2.28470E-01
4.75000E+00	3.051[illegible]7E+01	1.22500E+01	5.53134E-03
5.00000E+00	2.4867[illegible]E+00	1.25000E+01	4.12212E-02
5.25000E+00	1.18455E+00	1.27500E+01	2.31463E-01
5.50000E+00	9.43159E+00	1.30000E+01	3.29432E-02
5.75000E+00	2.00970E+00	1.32500E+01	1.84766E-01
6.00000E+00	2.94899E+00	1.35000E+01	7.13439E-02
6.25000E+00	2.65857E+00	1.37500E+01	2.27035E-01
6.50000E+00	3.87140E+00	1.40000E+01	2.60468E-01
6.75000E+00	3.62354E+00	1.42500E+01	2.51231E-01
7.00000E+00	2.32881E+00	1.45000E+01	1.49229E-01
7.25000E+00	1.47626E+00	1.47500E+01	8.02340E-02
7.50000E+00	3.07643E+00	1.50000E+01	3.13692E-01

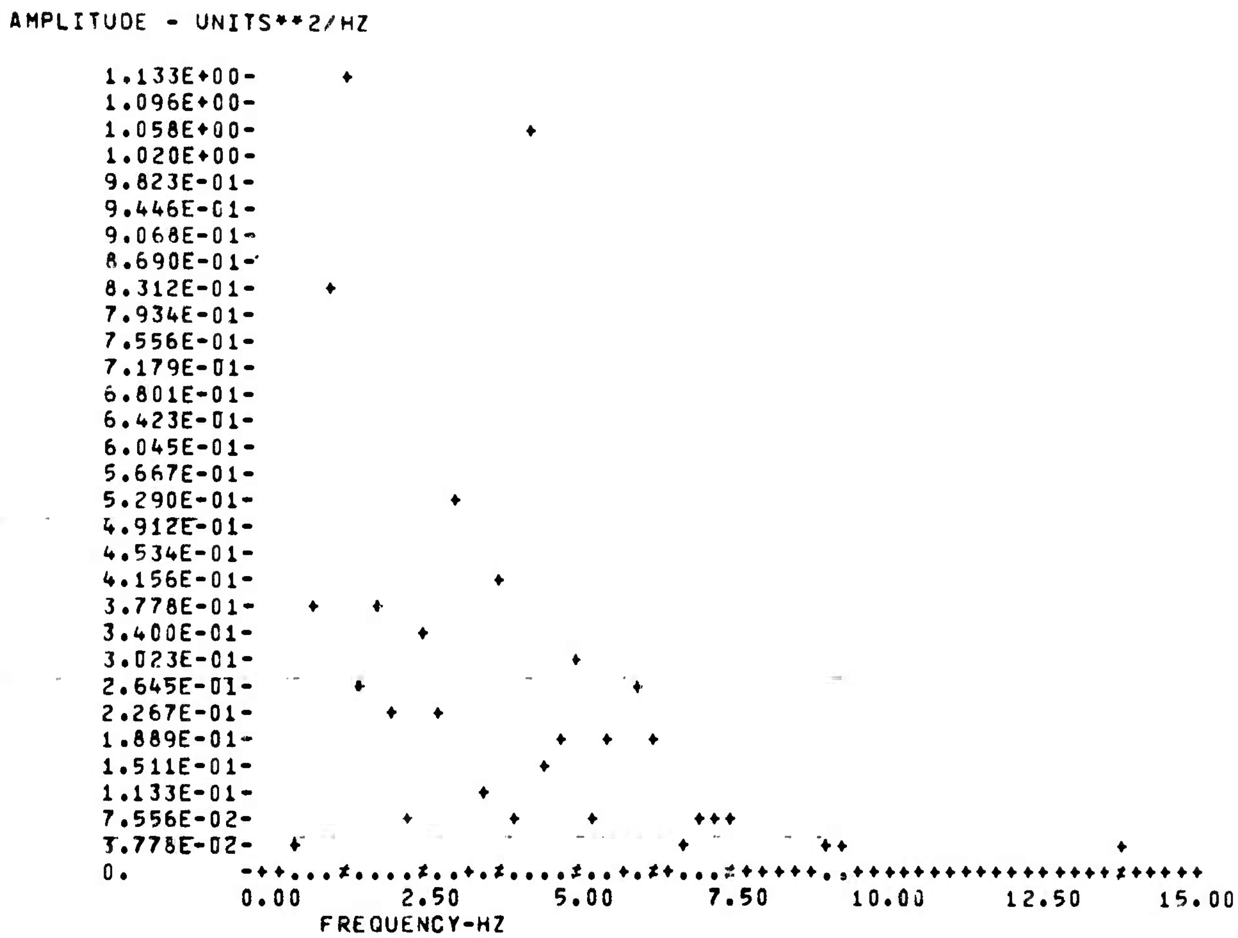
SPECTRAL DENSITY EDGE - X AXIS



SPECTRAL DENSITY EDGE - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	8.57811E-03
5.00000E-01	4.38723E-02
7.50000E-01	3.92989E-01
1.00000E+00	8.49705E-01
1.25000E+00	1.13347E+00
1.50000E+00	2.50274E-01
1.75000E+00	3.96698E-01
2.00000E+00	2.11382E-01
2.25000E+00	5.74244E-02
2.50000E+00	3.52915E-01
2.75000E+00	2.38410E-01
3.00000E+00	5.11231E-01
3.25000E+00	1.10213E-02
3.50000E+00	1.27360E-01
3.75000E+00	4.20598E-01
4.00000E+00	5.70440E-02
4.25000E+00	1.04597E+00
4.50000E+00	1.64019E-01
4.75000E+00	2.04174E-01
5.00000E+00	2.96962E-01
5.25000E+00	6.67351E-02
5.50000E+00	1.80274E-01
5.75000E+00	1.94416E-03
6.00000E+00	2.53886E-01
6.25000E+00	1.91712E-01
6.50000E+00	1.57403E-02
6.75000E+00	3.16388E-02
7.00000E+00	7.87592E-02
7.25000E+00	7.34126E-02
7.50000E+00	8.56458E-02
7.75000E+00	9.01209E-03
8.00000E+00	3.74410E-03
8.25000E+00	3.14803E-03
8.50000E+00	4.15014E-03
8.75000E+00	1.02569E-02
9.00000E+00	2.55435E-02
9.25000E+00	1.90078E-02
9.50000E+00	1.06209E-02
9.75000E+00	1.13056E-03
1.00000E+01	8.22518E-03
1.02500E+01	2.30056E-03
1.05000E+01	1.84212E-03
1.07500E+01	2.78336E-03
1.10000E+01	3.34122E-03
1.12500E+01	1.11997E-02
1.15000E+01	7.78489E-03
1.17500E+01	9.43554E-03
1.20000E+01	1.35036E-02
1.22500E+01	1.31622E-03
1.25000E+01	7.97969E-03
1.27500E+01	8.51312E-04
1.30000E+01	1.11164E-02
1.32500E+01	5.69364E-03
1.35000E+01	8.10829E-03
1.37500E+01	1.90124E-02
1.40000E+01	1.50747E-03
1.42500E+01	1.09640E-02
1.45000E+01	5.13959E-03
1.47500E+01	1.36584E-02
1.50000E+01	2.27331E-04

SPECTRAL DENSITY EDGE - Y AXIS



CDC 6600 CSP Printout VIII

Reference Program: Processing of IR data for aircraft target in wide field of view

Tracking Program: Run no. 94 using above referenced data

```
DIGITAL CORRELATION TRACKER - REFERENCING PROGRAM

 PROCESS 49 PICTURES
SEARCH WINDOW IS 16 X 16
STARTING TARGET COORDINATES ARE (44,59)
TAPE OUTPUT OPTION IS 1

CONTRAST ......NEG
```

COORDINATE ERROR ANALYSIS

STARTING COORDINATES * X= 59.00
Y= 44.00

****

NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR	NPIX	X ERROR	Y ERROR
1	0.00	0.00	2	.50	.13	3	.13	.25
4	.56	.38	5	.75	.19	6	1.19	.06
7	1.50	-.19	8	1.81	-.31	9	2.06	-.31
10	2.31	-.19	11	2.63	-.25	12	2.81	-.19
13	2.63	-.31	14	3.13	-.19	15	2.94	-.06
16	3.31	-.25	17	3.13	-.13	18	3.75	-.31
19	3.44	-.25	20	4.06	-.50	21	3.44	-.69
22	4.19	-.75	23	3.94	-.69	24	4.25	-.75
25	4.06	-.94	26	4.56	-.88	27	4.19	-1.00
28	4.88	-.94	29	4.56	-.69	30	5.06	-.88
31	5.56	-1.25	32	5.38	-1.13	33	5.56	-1.06
34	6.13	-.75	35	5.75	-.56	36	6.25	-.69
37	6.56	-1.00	38	7.25	-1.13	39	6.63	-1.00
40	7.94	-1.13	41	7.19	-1.31	42	8.56	-1.56
43	7.88	-1.44	44	8.69	-1.44	45	8.19	-1.31
46	8.88	-1.19	47	8.38	-1.38	48	9.56	-1.50
49	9.00	-1.44						

SIGNAL/NOISE DETERMINATION

SAMPLE	SIGNAL LEVEL	NOISE LEVEL	S/N
1	17.65	4.46	3.95
2	17.79	3.98	4.47
3	17.71	3.63	4.87
4	17.79	4.71	3.78

RESULTANT SIGNAL/NOISE = 4.269

```
TRACKING RUN NO. 94

X DIMENSION = 16      Y DIMENSION = 16
X CENTER = 32         Y CENTER = 32
PRINTOUT EVERY 99 FRAMES
INPUT FROM UNIT  1
  0 FRAMES SKIPPED,  49 FRAMES PROCESSED
FREQUENCY =  30.00
5 INPUT BITS USED
ICOLPS = 0      IOFF = 0
SCALOF =   4.00      SFACX =   5.00      SFACY =   5.00
AUTOMATIC THRESHOLD USED FOR EDGE TRACKER
LINEAR PROCESSING FOR CORRELATION TRACKER
CORRELATION METHOD - SUM OF ABS VALUES
UPDATE AT 10 FRAMES(SKIP)
LINEAR PROCESSING ABOVE THRESHOLD OF - 20 FOR CENTROID TRACKER

CENTROID - X AXIS  GAIN =     .90579

CENTROID - Y AXIS  GAIN =    1.03409

DIG CORR - X AXIS  GAIN =    1.00000

DIG CORR - Y AXIS  GAIN =    1.00000

EDGE - X AXIS      GAIN =     .39884

EDGE - Y AXIS      GAIN =     .71651
```

SAMPLE NO. 48 RUN NO. 94

INPUT PICTURE (X OFFSET = -3, Y OFFSET = -3)

INPUT DATA DIVIDED BY 2

#	3	#	8	9	6	3	3	3	3	3	5	3	3	2	2	1	3	3	2	3	3	3	2	2	2	3	4	1	1	5	4
Z	Z	Z	9	7	5	3	3	3	3	2	2	3	4	3	2	4	3	3	3	3	3	2	2	3	3	1	3	2	3	2	4
#	B	Z	Z	9	7	5	3	1	3	3	3	3	2	3	3	3	3	2	2	3	2	1	1	2	3	2	3	3	4	3	3
3	#	2	9	8	6	5	3	3	3	3	2	2	3	2	2	2	2	5	3	4	4	1	2	3	2	3	4	2	2	2	1
#	Z	#	Z	9	8	5	4	3	3	1	2	5	3	3	3	3	3	3	5	3	3	4	3	3	3	3	3	2	4	2	.
B	#	Z	9	8	3	3	3	3	1	3	3	4	3	4	5	4	2	2	3	3	5	3	3	3	1	3	2	3	2	2	2
Z	3	Z	#	8	6	3	3	3	5	3	3	4	6	7	6	5	5	4	4	4	3	5	3	2	1	3	3	3	2	3	1
Z	Z	#	9	6	4	2	3	3	3	3	4	4	9	#	Z	Z	#	#	8	5	4	3	2	1	4	3	2	3	1	2	1
Z	Z	9	9	8	6	4	3	3	3	5	8	Z	#	3	B	B	B	9	8	5	3	3	1	3	1	2	2	2	1	2	3
#	#	8	5	4	4	3	3	3	6	7	#	3	B	B	B	#	2	#	9	4	4	2	.	1	1	1	2	1	2	3	2
#	#	9	9	8	8	7	5	7	6	9	Z	Z	B	B	B	#	B	Z	9	6	.	.	.	.	.	.	.	1	1	1	1
Z	Z	Z	8	7	8	9	8	8	#	3	2	#	B	B	B	B	2	9	7	4	1	.	.	1	.	.	.	.	1	.	.
#	#	#	#	Z	9	8	9	8	#	#	#	3	#	B	B	B	#	2	9	7	4	2	.	1	1	.	2	.	1	.	.
#	#	9	9	8	8	7	8	8	Z	2	Z	B	B	B	B	#	Z	#	8	3	1	1	.	.	.	1	1	3	1	1	1
Z	Z	9	9	8	8	8	5	6	8	7	#	Z	B	B	B	B	B	#	#	5	3	.	.	1	1	2	3	2	2	1	.
Z	Z	9	9	7	5	5	5	6	6	9	#	#	B	B	B	B	2	9	3	3	2	1	1	.	.	3	.	1	.	.	.
3	Z	#	7	4	3	4	3	3	4	5	9	#	B	B	B	B	9	9	7	5	1	1	3	1	1	2	1	1	.	.	1
2	9	9	5	2	3	1	3	1	5	6	8	Z	3	3	Z	7	4	3	4	3	2	1	1	1	3	1	2	.	2	4	1
3	Z	8	5	6	3	1	3	1	3	3	4	3	5	7	8	6	4	3	3	3	3	2	1	1	2	3	1	4	2	3	2
#	9	7	3	4	3	1	2	3	3	3	2	3	3	3	3	3	3	3	3	2	3	2	2	3	3	2	3	2	2	3	3
2	9	7	5	3	3	.	1	2	1	3	4	2	2	4	3	4	3	3	2	3	4	3	1	3	3	3	3	2	3	3	3
Z	7	6	4	3	2	2	3	1	4	3	3	4	3	2	3	.	3	2	2	2	3	1	3	4	1	3	2	3	3	3	3
Z	9	7	5	5	2	5	3	4	2	2	3	2	3	3	3	4	2	2	3	3	2	2	3	3	3	3	3	3	5	3	1
#	7	4	3	3	2	3	1	3	2	3	3	4	4	3	3	2	2	.	1	3	2	3	3	3	3	6	3	3	2	2	3
Z	8	8	4	1	3	4	3	2	2	2	2	4	3	2	3	2	2	1	1	2	1	3	3	3	2	5	3	3	3	3	3
8	6	3	2	3	3	3	2	4	1	3	4	1	3	4	2	4	3	1	3	2	3	1	1	2	3	3	3	3	2	1	2
9	8	6	2	3	3	2	3	3	3	3	1	3	2	3	3	1	2	3	3	2	2	4	3	2	2	4	2	4	4	4	3
7	5	5	2	2	2	3	3	4	5	3	3	3	3	3	2	2	1	3	3	3	2	2	2	3	3	3	2	3	3	3	3
9	8	3	4	3	3	3	3	3	2	4	3	1	2	3	4	3	3	2	4	3	3	1	2	3	4	2	4	3	3	3	3
6	4	4	4	4	3	2	3	4	3	3	2	3	3	3	3	.	3	2	2	1	2	2	2	4	3	5	3	3	3	2	3
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

SAMPLE NO. 48 RUN NO. 94

VIDEO GRADIENTS

INPUT DATA DIVIDED BY 2

2	2	5	2	4	3	.	.	.	1	3	1	1	2	1	3	2	.	1	1	.	1	1	1	2	1	3	3	2	1	2	.
3	2	3	4	4	4	2	1	1	1	1	.	2	1	1	2	1	.	2	1	1	2	.	2	.	2	2	1	2	2	1	.
1	4	2	3	3	3	3	1	1	.	1	1	.	.	2	2	1	2	3	2	2	3	1	2	.	.	2	1	2	2	2	.
1	.	4	3	3	3	2	1	.	1	1	3	3	1	2	2	2	1	.	1	2	2	2	.	1	1	1	2	1	1	2	.
2	1	4	3	6	5	3	1	1	.	2	3	2	.	2	2	1	1	3	2	1	1	1	.	1	2	1	.	.	2	1	.
2	3	3	2	6	2	.	.	2	3	.	1	2	4	2	1	3	4	3	2	.	.	2	.	2	2	1	.	2	1	.	.
1	3	2	4	4	4	1	.	2	2	.	.	5	5	7	9	8	8	7	3	1	1	3	2	1	1	1	1	2	1	1	.
.	3	1	3	3	4	1	.	.	2	5	9	7	4	5	6	7	5	2	4	2	1	2	1	1	2	.	.	2	.	1	.
3	3	4	5	4	2	.	.	2	4	5	5	6	6	2	1	3	6	2	6	1	2	3	3	2	1	1	1	.	1	.	.
.	1	4	6	5	5	4	4	3	3	5	3	4	.	.	1	2	5	3	6	4	5	2	1	2	2	3	2	1	2	2	.
1	2	2	2	.	2	4	3	4	8	4	2	3	.	.	.	2	6	4	5	6	1	.	1	1	.	.	1	1	1	1	.
1	1	2	3	3	.	.	1	3	3	3	1	2	1	.	.	3	5	5	5	6	4	2	1	1	1	2	2	1	2	.	.
.	.	.	2	3	2	2	1	4	2	3	2	2	1	.	1	4	4	3	7	6	3	2	1	1	.	1	1	2	1	1	.
2	1	.	1	.	1	2	4	5	6	4	5	3	.	.	1	4	6	1	8	4	2	1	.	.	1	1	.	1	1	1	.
1	2	.	2	3	4	2	1	2	2	2	2	6	.	.	.	3	7	6	7	3	2	1	.	.	2	1	2	2	2	1	.
2	2	2	5	4	3	3	4	4	6	5	1	7	.	.	.	7	3	7	4	4	.	1	2	1	2	2	1	1	.	1	.
4	2	5	5	2	2	2	1	3	2	5	3	4	3	5	[illegible]	2	8	7	4	4	.	2	1	1	1	.	.	.	4	3	.
3	3	4	3	3	2	2	2	4	3	6	9	2	2	7	6	3	1	1	1	1	2	.	.	1	1	1	3	3	2	3	.
5	5	6	3	3	2	2	1	2	.	1	2	2	5	6	6	3	.	.	.	.	1	.	2	2	.	.	1	2	1	.	.
3	2	5	1	1	3	2	1	2	1	1	1	1	2	1	1	1	.	1	.	1	2	1	2	.	1	1	1	1	1	.	.
5	3	3	2	1	2	2	.	1	2	.	1	2	1	1	3	3	1	.	.	1	2	.	2	1	1	.	.	.	.	.	.
4	3	3	2	3	3	2	2	1	2	1	1	1	.	1	3	2	1	1	.	.	2	2	1	2	1	.	.	2	2	1	.
4	5	3	2	3	3	3	3	3	.	1	2	2	1	.	2	1	1	2	1	.	1	1	.	.	3	3	.	2	4	.	.
4	4	4	2	1	1	2	.	1	1	2	2	1	1	.	2	.	2	1	2	1	2	.	.	1	4	4	.	1	1	1	.
4	5	6	1	2	.	1	1	2	1	2	.	2	.	.	.	2	1	2	1	1	.	3	2	.	3	2	.	1	2	1	.
3	4	4	2	.	1	.	1	1	2	2	1	1	1	.	1	2	.	1	1	.	1	3	.	1	2	2	2	3	3	2	.
4	3	5	1	2	.	1	1	3	2	2	2	.	.	.	2	.	2	.	.	.	1	2	.	2	1	2	2	1	1	1	.
4	3	1	2	2	1	.	1	3	1	1	2	2	1	2	2	2	.	2	1	1	1	.	2	1	2	1	1	.	.	.	.
6	4	1	1	.	1	.	1	1	1	2	1	2	1	1	4	2	1	2	3	2	1	.	3	.	.	1	1	.	1	1	.
2	3	3	3	4	5	5	4	4	5	5	5	4	5	5	7	7	5	6	7	7	6	6	5	4	4	3	5	5	6	6	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

SAMPLE NO. 48   RUN NO. 94

EDGE TRACKER INPUT DATA

INPUT DATA DIVIDED BY 1

```
. . 1 . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . 1 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
. 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . 1 . 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . 1 . . . . . . . . 1 . . . 1 . . . . . . . . . . . . . .
. . . 1 1 1 . . . . . . 1 1 1 1 1 1 1 . . . . . . . . . . . . .
. . . . . 1 . . . . 1 1 1 1 1 1 1 1 . 1 . . . . . . . . . . . .
. . 1 1 1 . . . . 1 1 1 1 1 . . . 1 . 1 . . . . . . . . . . . .
. . 1 1 1 1 1 1 . . 1 . 1 . . . . 1 . 1 1 1 . . . . . . . . . .
. . . . . . 1 . 1 1 1 . . . . . . 1 1 1 1 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 1 1 1 1 1 . . . . . . . . . .
. . . . . . . . 1 . . . . . . . 1 1 . 1 1 . . . . . . . . . . .
. . . . . . . 1 1 1 1 1 . . . . 1 1 . 1 1 . . . . . . . . . . .
. . . . . 1 . . . . . . 1 . . . . 1 1 1 . . . . . . . . . . . .
. . . 1 1 . . 1 1 1 1 . 1 . . . 1 . 1 1 1 . . . . . . . . . . .
1 . 1 1 . . . . . . 1 . 1 . 1 1 1 1 1 1 1 . . . . . . . . 1 . .
. . 1 . . . . . 1 . 1 1 1 1 1 1 . . . . . . . . . . . . . . . .
1 1 1 . . . . . . . . . . 1 1 1 . . . . . . . . . . . . . . . .
. . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . .
1 1 1 . . . . . . . . . . . . . . . . . . . . . . . 1 1 . . . . .
1 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
1 1 . . . . . . . . . . . . . 1 . . . . . . . . . . . . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 48 RUN NO. 94

DCT TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

K	3	K	B	9	6	3	3	3	3	3	5	3	3	2	2	1	3	3	2	3	3	3	2	2	2	3	4	1	1	5	4
Z	Z	2	9	7	5	3	3	3	3	2	2	3	4	3	2	4	3	3	3	3	3	2	2	3	3	1	3	2	3	2	4
K	S	Z	Z	9	7	5	3	1	3	3	3	3	2	3	3	3	3	2	2	3	2	1	1	2	3	2	3	3	4	3	3
3	K	2	9	8	6	5	3	3	3	3	2	2	3	2	2	2	2	5	3	4	4	1	2	3	2	3	4	2	2	2	1
K	2	K	Z	9	8	5	4	3	3	1	2	5	3	3	3	3	3	3	5	3	3	4	3	3	3	3	3	2	4	2	.
S	K	Z	9	8	3	3	3	3	1	3	3	4	3	4	5	4	2	2	3	3	5	3	3	3	1	3	2	3	2	2	2
2	3	2	B	8	6	3	3	3	5	3	3	4	6	7	6	5	5	4	4	4	3	5	3	2	1	3	3	3	2	3	1
Z	Z	B	9	6	4	2	3	3	3	3	4	4	9	B	Z	Z	B	B	8	5	4	3	2	1	4	3	2	3	1	2	1
Z	Z	9	9	8	6	4	3	3	3	5	8	Z	B	3	S	S	S	9	8	5	3	3	1	3	1	2	2	2	1	2	3
B	B	8	5	4	4	3	3	3	6	7	B	3	S	S	S	K	2	B	9	4	4	2	.	1	1	1	2	1	2	3	2
B	B	9	9	8	8	7	5	7	6	9	Z	Z	S	S	S	S	S	Z	9	6	.	.	.	.	.	.	.	1	1	1	1
Z	Z	Z	8	7	8	9	8	8	B	3	Z	K	S	S	S	S	2	9	7	4	1	.	.	1	.	.	.	.	1	.	.
B	B	B	B	Z	9	8	9	8	B	B	K	3	K	S	S	S	K	2	9	7	4	2	.	1	1	.	2	.	1	.	.
B	B	9	9	8	8	7	8	8	Z	Z	Z	S	S	S	S	K	Z	B	8	3	1	1	.	.	.	1	1	3	1	1	1
Z	Z	9	9	8	8	8	5	6	8	7	B	2	S	S	S	S	B	B	B	5	3	.	.	1	1	2	3	2	2	1	.
Z	Z	9	9	7	5	5	5	6	6	9	B	B	S	S	S	S	2	9	3	3	2	1	1	.	.	3	.	1	.	.	.
3	Z	B	7	4	3	4	3	3	4	5	9	B	S	S	S	S	9	9	7	5	1	1	3	1	1	2	1	1	.	.	1
Z	9	9	5	2	3	1	3	1	5	6	8	Z	3	3	Z	7	4	3	4	3	2	1	1	1	3	1	2	.	2	4	1
3	Z	8	5	6	3	1	3	1	3	3	4	3	5	7	8	6	4	3	3	3	3	2	1	1	2	3	1	4	2	3	2
B	9	7	3	4	3	1	2	3	3	3	2	3	3	3	3	3	3	3	3	2	3	2	2	3	3	2	3	2	2	3	3
Z	9	7	5	3	3	.	1	2	1	3	4	2	2	4	3	4	3	3	2	3	4	3	1	3	3	3	3	2	3	3	3
Z	7	6	4	3	2	2	3	1	4	3	3	4	3	2	3	.	3	2	2	2	3	1	3	4	1	3	2	3	3	3	3
Z	9	7	5	5	2	5	3	4	2	2	3	2	3	3	3	4	2	2	3	3	2	2	3	3	3	3	3	3	5	3	1
B	7	4	3	3	2	3	1	3	2	3	3	4	4	3	3	2	2	.	1	3	2	3	3	3	3	6	3	3	2	2	3
Z	8	8	4	1	3	4	3	2	2	2	2	4	3	2	3	2	2	1	1	2	1	3	3	3	2	5	3	3	3	3	3
8	6	3	2	3	3	3	2	4	1	3	4	1	3	4	2	4	3	1	3	2	3	1	1	2	3	3	3	3	2	1	2
9	8	6	2	3	3	2	3	3	3	3	1	3	2	3	3	1	2	3	3	2	2	4	3	2	2	4	2	4	4	4	3
7	5	5	2	2	2	3	3	4	5	3	3	3	3	3	2	2	1	3	3	3	2	2	2	3	3	3	2	3	3	3	3
9	8	3	4	3	3	3	3	3	2	4	3	1	2	3	4	3	3	2	4	3	3	1	2	3	4	2	4	3	3	3	3
6	4	4	4	4	3	2	3	4	3	3	2	3	3	3	3	.	3	2	2	1	2	2	2	4	3	5	3	3	3	2	3
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

SAMPLE NO. 48   RUN NO. 94

CENTROID TRACKER INPUT DATA

INPUT DATA DIVIDED BY 2

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K 3 K B . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Z Z Z . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
K B Z Z . . . . . . . . . . . . . . . . . . . . . . . . . . . .
3 K Z . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
K Z K Z . . . . . . . . . . . . . . . . . . . . . . . . . . . .
B K Z . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Z 3 Z B . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Z Z B . . . . . . . . . . . B Z Z B B . . . . . . . . . . . . .
Z Z . . . . . . . . . . Z B 3 B B B . . . . . . . . . . . . . .
B B . . . . . . . . . B 3 B B B K Z B . . . . . . . . . . . . .
B B . . . . . . . . . Z Z B B B B B Z . . . . . . . . . . . . .
Z Z Z . . . . . . B 3 Z K B B B B Z . . . . . . . . . . . . . .
B B B B Z . . . . B B K 3 K B B B K Z . . . . . . . . . . . . .
B B . . . . . . . Z Z Z B B B B K Z B . . . . . . . . . . . . .
Z Z . . . . . . . . . B Z B B B B B B B . . . . . . . . . . . .
Z Z . . . . . . . . . B B B B B B Z . . . . . . . . . . . . . .
3 Z B . . . . . . . . . B B B B B . . . . . . . . . . . . . . .
Z . . . . . . . . . . . Z 3 3 Z . . . . . . . . . . . . . . . .
3 Z . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
B . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Z . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Z . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Z . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
B . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Z . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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SAMPLE NO. 48   RUN NO. 94

CORRELATION REFERENCE MATRIX

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 9 7 4 3 3 6 5 6 6 8 7 5 5 5 4 4
 7 7 4 5 7 6 6 9 7 8 8 9 6 5 5 4
 5 5 5 4 6 8 91213131212 9 9 7 5
 4 4 5 5 811132024242320181511 9
 4 3 4 81117212428303128231917 11
 6 6 8111620273031303026221917 10
14121117212227303030302924221811
18181721272630293031313126211710
18182020242629303130303027242013
15161621212128303130302926191611
11111015172028303131313123191512
 7 9 91217202529303131292015 12 5
 6 7 9 81419202629282720151211 5
 4 5 3 7111316212220171 0 7 6 6 2
 0 4 3 4 5 5 6 71111 9 8 6 5 5 4
 0 3 5 5 4 5 5 3 7 5 7 6 5 4 5 6
```

TRACKING ERRORS

EDGE ERRORS XM= -1.6113   YM= -2.0119   XC= 1.3887   YC=   .5506

CENTROID ERRORS XM= -2.5267   YM= -3.3033   XC=   .4733   YC= -.7408

CORRELATION ERRORS XM= -2.3047   YM= -3.7825   XC=   .6953   YC= -1.2200

FRAME OFFSETS -3   -3   INPUT INCR. ERRORS   0.0000   .4375

FINAL SEARCH CORRELATIONS -
1.18E+03   9.42E+02   1.43E+03   5.86E+02   5.50E+02   1.12E+03   9.34E+02   7.66E+02   1.34E+03

STATISTICAL DATA

	RESOLUTION ELEMENTS				REGRESSION COEF	
CENTROID - X AXIS	MEAN	1.518980E-01	RMS	3.926469E-01	BETA	9.503707E-04
CENTROID - Y AXIS	MEAN	-3.073107E-01	RMS	1.685148E-01	BETA	-1.552459E-02
RADIAL ERROR(RMS)= .4273			DRIFT DISTANCE= .7466			
DIG CORR - X AXIS	MEAN	4.787201E-01	RMS	2.479122E-01	BETA	7.186852E-03
DIG CORR - Y AXIS	MEAN	-5.188551E-01	RMS	9.642534E-02	BETA	-2.699325E-02
RADIAL ERROR(RMS)= .2660			DRIFT DISTANCE= 1.3408			
EDGE - X AXIS	MEAN	-1.096926E+00	RMS	1.213963E+00	BETA	-2.989207E-02
EDGE - Y AXIS	MEAN	1.227311E-01	RMS	5.509318E-01	BETA	2.157703E-03
RADIAL ERROR(RMS)= 1.3331			DRIFT DISTANCE= 1.4386			

TRACKING ERRORS

CENTROID - X AXIS

-.3229	-.5876	-.4424	-.0452	-.1075	.3469	.3571	-.0442	.5616	.7894
.8970	.4924	.9405	.5641	-1.8210	.7256	.4168	.3294	.3373	-.1903
.0950	.2633	.4694	-.7043	.1144	.2229	-.3391	-.0968	-.3273	.0487
.1162	.1419	.1426	.0958	.2489	.7115	.2899	.2523	.4072	.8658
.8102	-1.6911	-.6042	.6208	.5220	.1227	.4307	.2105		

CENTROID - Y AXIS

.1360	.4786	.1477	.1843	.0904	.1499	.0265	.0156	.1359	.0676
-.1438	-.1490	-.3584	-.2362	-.5227	-.0401	-.4365	-.8834	-.4962	-.0511
-.2039	-.1927	.0873	-1.0277	-.0433	-.7581	-.1681	-.6024	-.1234	-.4248
-.4258	-.5712	-.2743	-.2430	-.2934	-.6027	-.3529	-.9256	-.4789	-.7168
-.6598	.1556	-.6747	-.5037	-.6113	-.5047	-.8086	-.6318		

DIG CORR - X AXIS

.1763	.0010	.1707	-.0615	.1132	.2254	.4350	.2815	.5389	.5773
.8711	.6932	.9576	.7983	.9240	.7228	.7999	.5042	.5187	.4407
.3898	.2299	.4397	.2998	.3514	.2292	.1335	.0232	.1484	.1401
.1907	.3348	.3511	.4012	.5000	.5587	.5280	.6145	.7866	.7830
.8475	.6834	.8017	.6425	.8187	.6081	.8007	.6953		

DIG CORR - Y AXIS

.0957	.1979	.2172	.0880	-.0171	-.1410	-.1006	-.1680	-.1490	-.2258
-.1521	-.2552	-.2675	-.2648	-.2811	-.2506	-.2026	-.4141	-.3330	-.4109
-.4017	-.4248	-.3745	-.4912	-.4854	-.6478	-.6296	-.6314	-.6050	-.7738
-.5521	-.7621	-.5709	-.5122	-.5434	-.7004	-.7220	-.7507	-.8362	-1.0782
-.9410	-1.1386	-1.1526	-1.2438	-1.1559	-1.2184	-1.1907	-1.2200		

EDGE - X AXIS

-2.2544	-2.6579	-2.2382	.1270	-1.9981	1.7716	1.0250	-1.9023	2.0857	-2.7763
1.4500	-2.0049	.7476	.2034	-1.8032	.4076	-2.4140	.3341	-.9252	-3.6616
-1.5778	1.8659	-.2334	-4.7610	.9041	-1.1284	-1.5691	-1.0324	-4.9062	-1.0151
-.4015	-.4794	-3.8035	-1.4573	-.3645	-1.0028	-.3506	-.8498	-1.0467	.0162
2.4636	-6.1877	-6.5017	-1.8548	-1.6200	-.6577	-.2772	-1.0400		

EDGE - Y AXIS

.1133	.7364	.2234	.7137	-.0470	.0148	-.3356	1.0928	-.4157	.4245
-.1146	.7691	.1664	-.5655	.5347	.6149	.4413	-.7729	.1258	.6758
.0603	-.2110	.1339	-2.3243	.1895	.1220	.3064	.5979	.9109	-.5733
.0102	-1.0247	.3643	-.5247	.8386	-.9423	-.7387	-.4664	-.5594	-.0059
.2137	2.8771	.4897	1.1316	.3283	.8155	-.2472	-.2454		

FILTERED TRACKER DATA

CENTROID - X AXIS

0.0000	0.0000	-.3891	-.4331	-.2107	.1322	.3618	.2801	.2764	.5085
.8256	.8205	.7796	.6886	-.3028	-.5619	-.0804	.5024	.5722	.1993
-.0605	.0027	.2927	.0562	-.1641	-.0873	-.0373	-.0939	-.2390	-.1828
-.0025	.1550	.1942	.1467	.1543	.3094	.5045	.4139	.3153	.5107
.7803	-.0539	-.9000	-.6313	.2724	.6436	.5164	.2737		

CENTROID - Y AXIS

0.0000	0.0000	.2170	.2954	.1891	.1086	.0595	.0297	.0557	.0867
.0105	-.1132	-.2637	-.3149	-.3949	-.3003	-.2767	-.5134	-.6839	-.4731
-.1785	-.0736	-.0307	-.3870	-.4942	-.5769	-.4235	-.4142	-.3190	-.3114
-.3585	-.4852	-.4637	-.3321	-.2384	-.3632	-.4614	-.6610	-.6912	-.6831
-.6515	-.3438	-.2665	-.3895	-.5910	-.6190	-.6664	-.6872		

DIG CORR - X AXIS

0.0000	0.0000	.0914	.0737	.0573	.1152	.2892	.3783	.4497	.5242
.6998	.7888	.8674	.8684	.8825	.8260	.7810	.6569	.5383	.4502
.4046	.3233	.3228	.3346	.3502	.3021	.2072	.0863	.0578	.1012
.1684	.2572	.3361	.3918	.4488	.5182	.5546	.5826	.6715	.7696
.8389	.7970	.7587	.7029	.7252	.7032	.7221	.7246		

DIG CORR - Y AXIS

0.0000	0.0000	.1553	.2062	.1047	-.0618	-.1494	-.1705	-.1584	-.1788
-.1849	-.2102	-.2454	-.2649	-.2721	-.2649	-.2674	-.3264	-.3681	-.3950
-.4022	-.4144	-.4045	-.4285	-.4690	-.5591	-.6318	-.6578	-.6345	-.6709
-.6582	-.6794	-.6507	-.5808	-.5214	-.5750	-.6816	-.7585	-.8065	-.9273
-1.0042	-1.0738	-1.1270	-1.1989	-1.2131	-1.2076	-1.1949	-1.2025		

EDGE - X AXIS

0.0000	0.0000	-1.9668	-2.0080	-1.4249	.0539	1.1283	.3933	.2122	-.7521
-.4132	-.7068	-.3147	.0807	-.3741	-.5631	-1.2317	-.9649	-.6902	-1.6549
-2.4328	-.9772	.5447	-1.0098	-1.7803	-1.4416	-.9390	-1.0182	-2.6184	-2.9833
-1.8207	-.3812	-1.2387	-2.2532	-1.0645	-.9037	-.3187	-.4344	-.8175	-.6993
.7110	-1.0427	-4.7219	-5.6035	-3.4086	-.0654	.1670	-.1985		

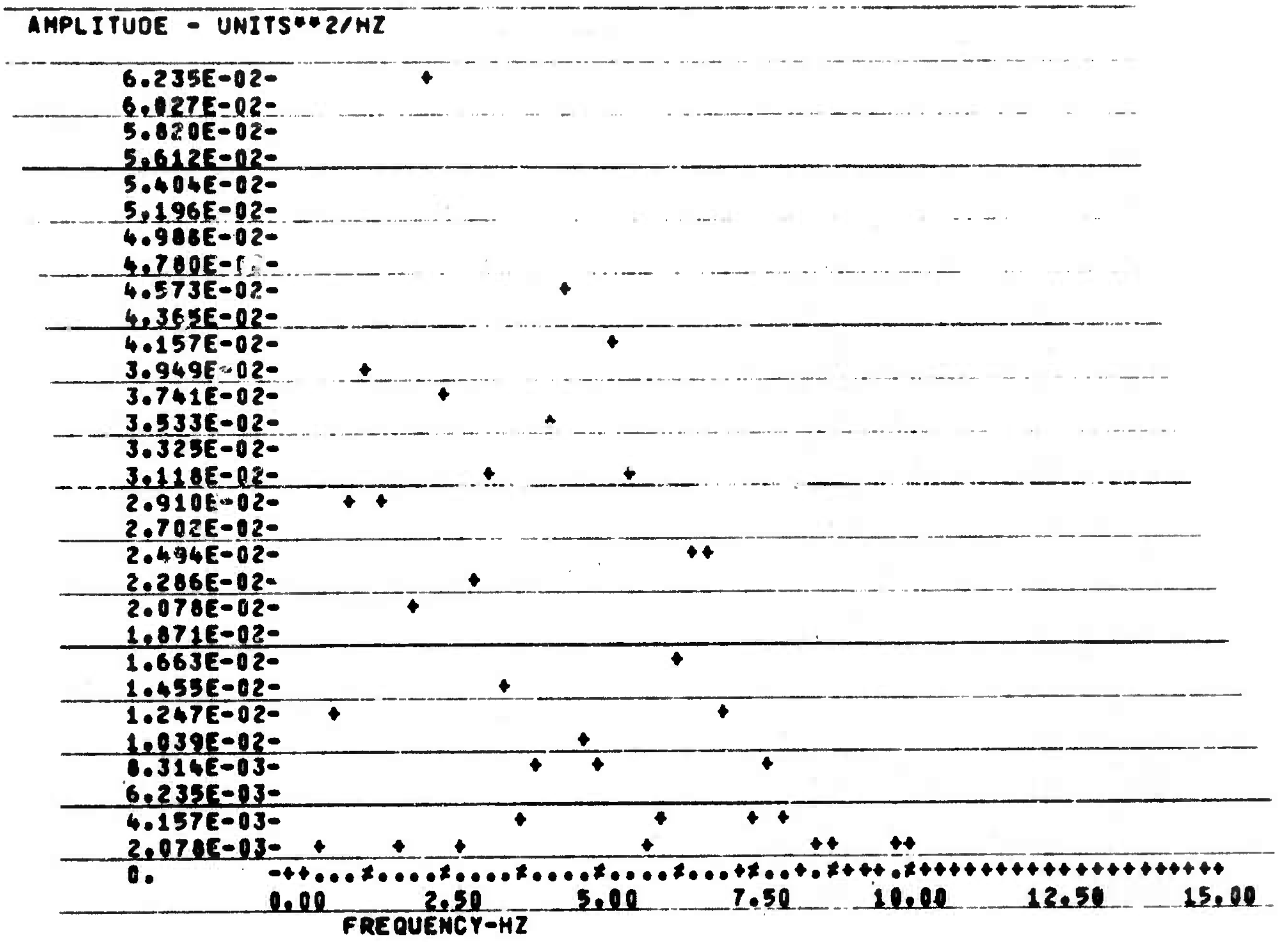
EDGE - Y AXIS

0.0000	0.0000	.3183	.6102	.4307	.1121	-.2184	.1720	.2746	.2834
.0733	.2651	.3044	.0530	-.0391	.2719	.5886	.1384	-.2427	.8141
.3289	.2880	-.0898	-.9539	-1.0774	-.4708	.3021	.6583	.8017	.3285
-.1324	-.6518	-.4504	-.2557	.2405	.0185	-.5054	-.7969	-.6974	-.3249
.0662	1.3078	1.7131	1.4381	.6919	.4454	.1887	-.1884		

SPECTRAL DENSITY CENTROID - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	7.18415E-05
5.00000E-01	2.52158E-03
7.50000E-01	1.31081E-02
1.00000E+00	2.87511E-02
1.25000E+00	3.96864E-02
1.50000E+00	2.89092E-02
1.75000E+00	2.05489E-03
2.00000E+00	1.99660E-02
2.25000E+00	6.23527E-02
2.50000E+00	3.77585E-02
2.75000E+00	1.36696E-03
3.00000E+00	2.23075E-02
3.25000E+00	3.22050E-02
3.50000E+00	1.37956E-02
3.75000E+00	4.00752E-03
4.00000E+00	7.33990E-03
4.25000E+00	3.57593E-02
4.50000E+00	4.65621E-02
4.75000E+00	1.08436E-02
5.00000E+00	8.04571E-03
5.25000E+00	4.08508E-02
5.50000E+00	3.06268E-02
5.75000E+00	2.60487E-03
6.00000E+00	5.00205E-03
6.25000E+00	1.64972E-02
6.50000E+00	2.41490E-02
6.75000E+00	2.55618E-02
7.00000E+00	1.15175E-02
7.25000E+00	1.23668E-04
7.50000E+00	5.03537E-03
7.75000E+00	8.57645E-03
8.00000E+00	3.41376E-03
8.25000E+00	4.60852E-04
8.50000E+00	1.57544E-03
8.75000E+00	1.92524E-03
9.00000E+00	9.28156E-04
9.25000E+00	9.30209E-05
9.50000E+00	6.40891E-04
9.75000E+00	1.82315E-03
1.00000E+01	1.52696E-03
1.02500E+01	3.88630E-04
1.05000E+01	2.33713E-04
1.07500E+01	4.09074E-04
1.10000E+01	1.72006E-04
1.12500E+01	6.38803E-05
1.15000E+01	5.72204E-05
1.17500E+01	1.58947E-05
1.20000E+01	2.32797E-04
1.22500E+01	5.54878E-04
1.25000E+01	5.47687E-04
1.27500E+01	3.99739E-04
1.30000E+01	9.23895E-04
1.32500E+01	5.08009E-04
1.35000E+01	1.63458E-04
1.37500E+01	4.23946E-05
1.40000E+01	3.96466E-05
1.42500E+01	1.31830E-05
1.45000E+01	1.88998E-04
1.47500E+01	1.88526E-04
1.50000E+01	5.01134E-05

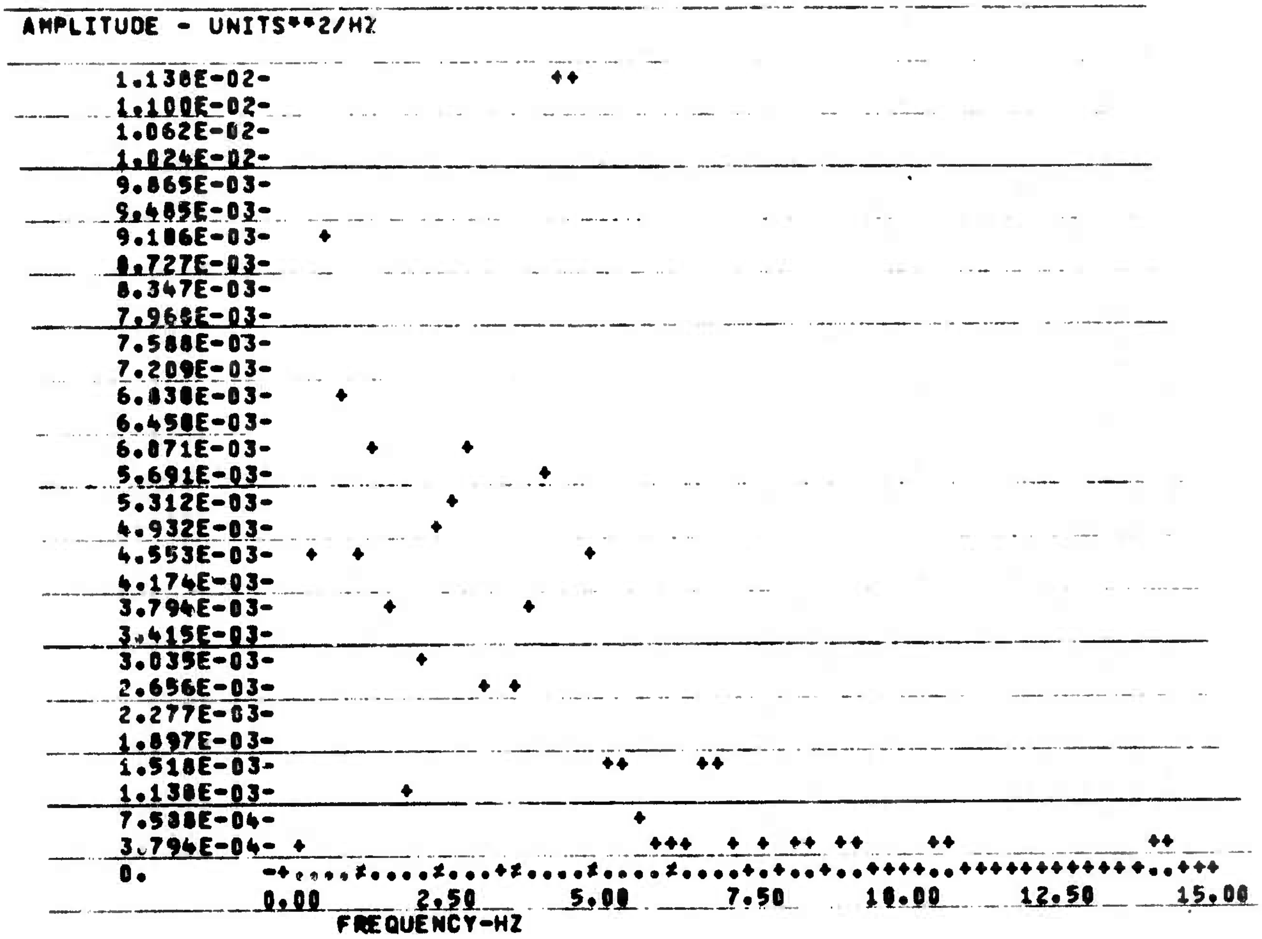
SPECTRAL DENSITY CENTROID - X AXIS



SPECTRAL DENSITY CENTROID - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	4.85680E-04	7.75000E+00	2.68635E-04
5.00000E-01	4.57499E-03	8.00000E+00	6.26450E-05
7.50000E-01	8.98296E-03	8.25000E+00	2.68574E-04
1.00000E+00	6.93014E-03	8.50000E+00	2.93676E-04
1.25000E+00	4.71651E-03	8.75000E+00	1.59010E-04
1.50000E+00	6.12088E-03	9.00000E+00	4.91162E-04
1.75000E+00	3.91120E-03	9.25000E+00	5.21768E-04
2.00000E+00	1.01644E-03	9.50000E+00	1.25391E-04
2.25000E+00	3.22179E-03	9.75000E+00	6.56693E-06
2.50000E+00	4.95061E-03	1.00000E+01	1.16015E-05
2.75000E+00	5.45720E-03	1.02500E+01	4.74811E-05
3.00000E+00	6.26029E-03	1.05000E+01	2.00825E-04
3.25000E+00	2.81214E-03	1.07500E+01	2.07102E-04
3.50000E+00	3.01037E-05	1.10000E+01	7.22507E-05
3.75000E+00	2.61084E-03	1.12500E+01	3.24703E-06
4.00000E+00	3.79860E-03	1.15000E+01	8.14396E-06
4.25000E+00	5.62338E-03	1.17500E+01	1.34107E-05
4.50000E+00	1.13825E-02	1.20000E+01	3.29535E-05
4.75000E+00	1.12157E-02	1.22500E+01	9.86281E-05
5.00000E+00	4.68495E-03	1.25000E+01	1.32777E-04
5.25000E+00	1.67291E-03	1.27500E+01	1.22994E-04
5.50000E+00	1.61749E-03	1.30000E+01	1.07195E-04
5.75000E+00	7.73756E-04	1.32500E+01	4.71825E-05
6.00000E+00	3.20243E-04	1.35000E+01	2.62930E-05
6.25000E+00	2.34721E-04	1.37500E+01	1.39817E-04
6.50000E+00	5.32234E-04	1.40000E+01	2.56884E-04
6.75000E+00	1.50916E-03	1.42500E+01	2.49828E-04
7.00000E+00	1.34717E-03	1.45000E+01	1.68440E-04
7.25000E+00	2.93303E-04	1.47500E+01	9.90181E-05
7.50000E+00	1.80389E-04	1.50000E+01	7.43029E-05

SPECTRAL DENSITY CENTROID - Y AXIS

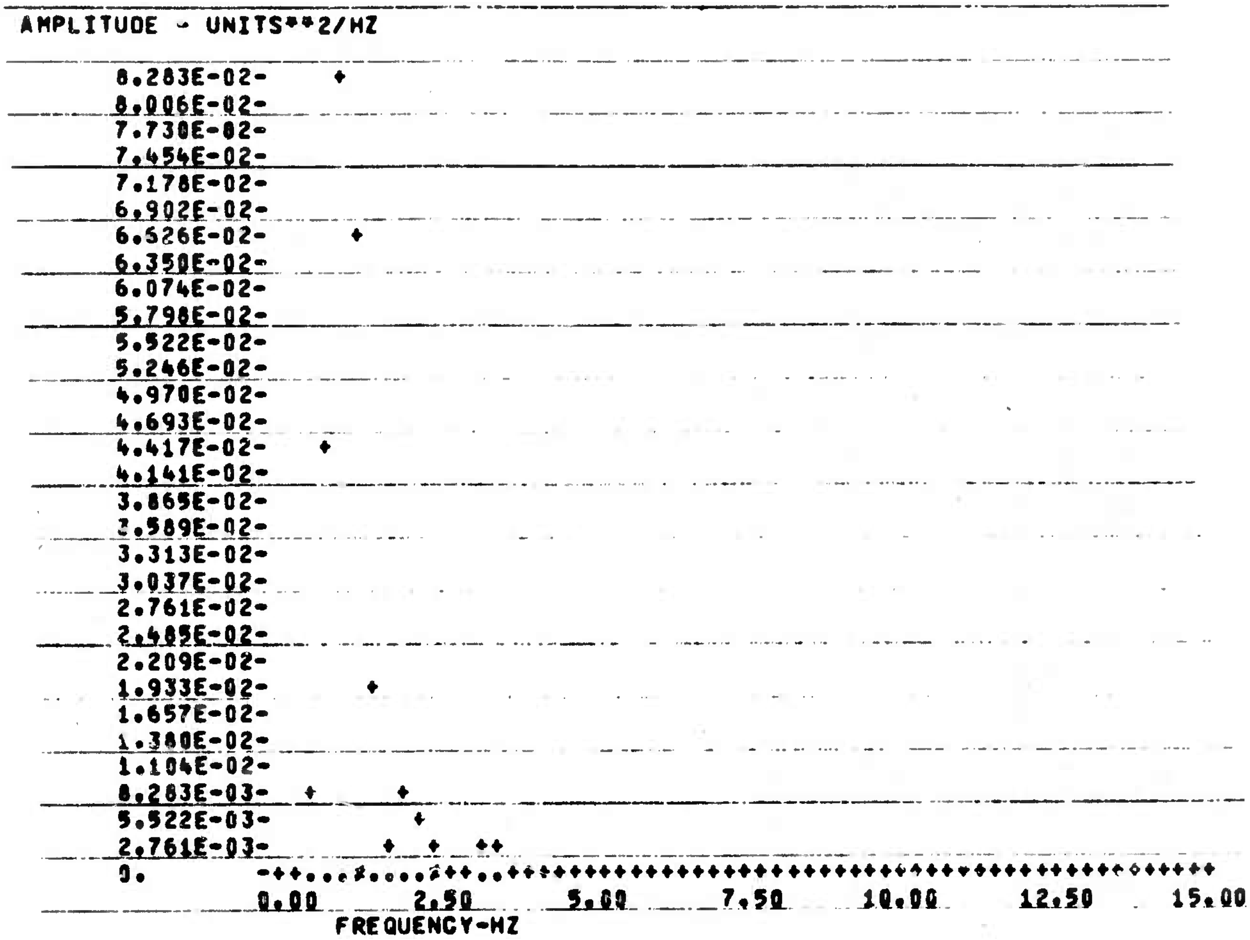


SPECTRAL DENSITY DIG CORR - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.97087E-04
5.00000E-01	8.07960E-03
7.50000E-01	4.41128E-02
1.00000E+00	8.28258E-02
1.25000E+00	6.54760E-02
1.50000E+00	1.91553E-02
1.75000E+00	3.59318E-03
2.00000E+00	7.19709E-03
2.25000E+00	5.06732E-03
2.50000E+00	1.44635E-03
2.75000E+00	2.56061E-04
3.00000E+00	3.86635E-04
3.25000E+00	1.45663E-03
3.50000E+00	1.96707E-03
3.75000E+00	9.18387E-04
4.00000E+00	3.16964E-04
4.25000E+00	7.76771E-04
4.50000E+00	4.09334E-04
4.75000E+00	9.94420E-06
5.00000E+00	7.96025E-05
5.25000E+00	2.61999E-05
5.50000E+00	3.08788E-04
5.75000E+00	2.45208E-04
6.00000E+00	6.88401E-06
6.25000E+00	2.84098E-04
6.50000E+00	4.06849E-04
6.75000E+00	3.32963E-04
7.00000E+00	3.10723E-04
7.25000E+00	3.28063E-04
7.50000E+00	2.21840E-04

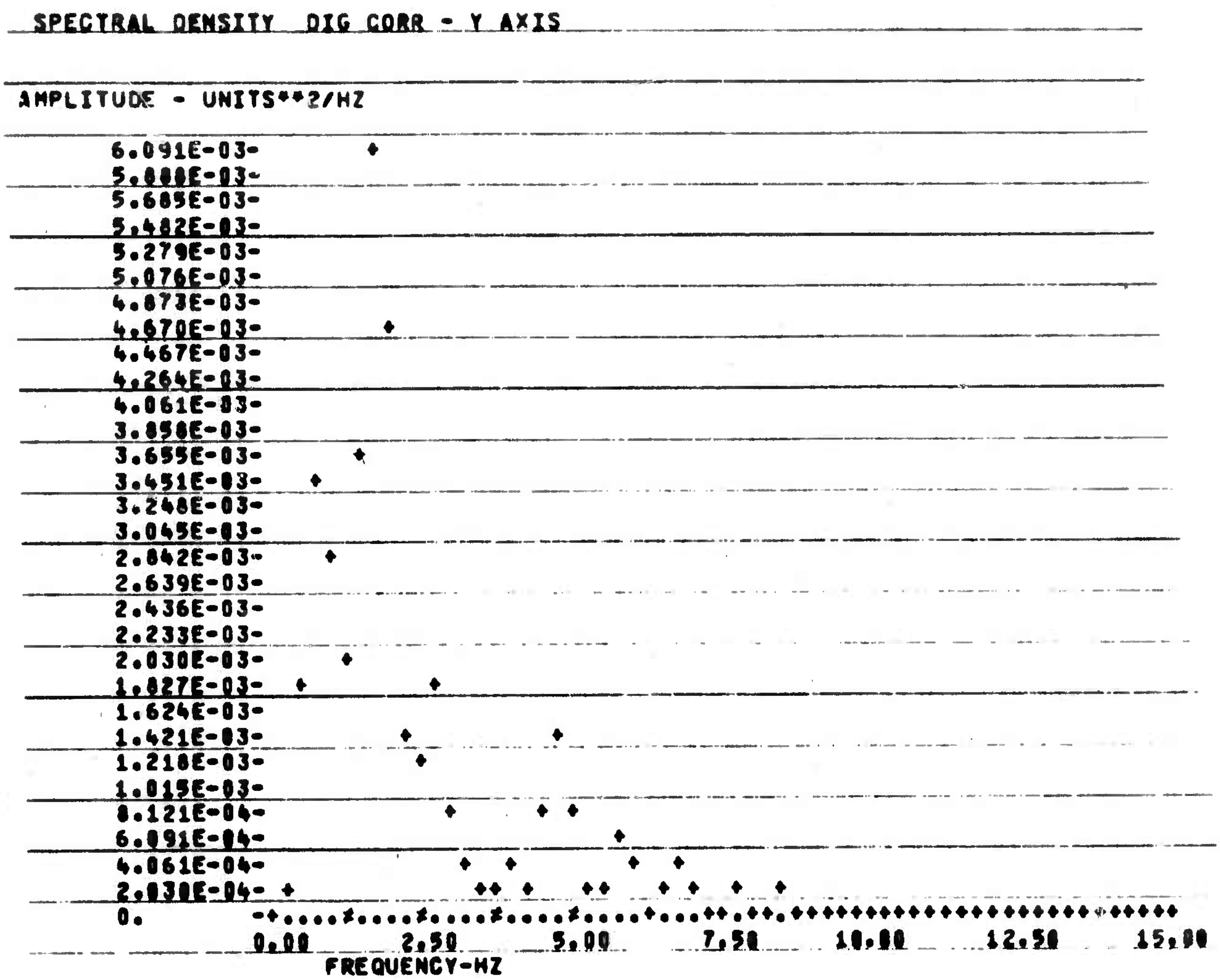
FREQ - HZ	AMP - UNITS**2/HZ
7.75000E+00	9.33414E-05
8.00000E+00	2.46462E-04
8.25000E+00	1.99869E-04
8.50000E+00	6.17869E-05
8.75000E+00	1.39017E-04
9.00000E+00	7.90721E-05
9.25000E+00	2.55459E-05
9.50000E+00	1.50304E-05
9.75000E+00	3.72274E-05
1.00000E+01	1.12711E-04
1.02500E+01	4.23113E-05
1.05000E+01	3.20147E-05
1.07500E+01	4.07816E-05
1.10000E+01	1.26514E-05
1.12500E+01	5.73670E-05
1.15000E+01	2.33512E-05
1.17500E+01	3.33223E-05
1.20000E+01	4.64743E-05
1.22500E+01	5.80830E-06
1.25000E+01	4.13983E-05
1.27500E+01	1.47963E-05
1.30000E+01	2.85992E-05
1.32500E+01	7.17320E-05
1.35000E+01	1.22978E-05
1.37500E+01	3.86610E-05
1.40000E+01	7.30543E-05
1.42500E+01	3.31526E-05
1.45000E+01	3.48675E-05
1.47500E+01	3.81522E-05
1.50000E+01	2.65355E-05

SPECTRAL DENSITY DIG CORR - X AXIS



SPECTRAL DENSITY DIG CORR - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	1.97787E-04	7.75000E+00	1.39247E-04
5.00000E-01	1.78693E-03	8.00000E+00	2.42628E-05
7.50000E-01	3.42299E-03	8.25000E+00	4.52396E-05
1.00000E+00	2.79750E-03	8.50000E+00	1.36041E-04
1.25000E+00	2.01142E-03	8.75000E+00	3.22906E-05
1.50000E+00	3.69059E-03	9.00000E+00	1.37123E-05
1.75000E+00	6.09087E-03	9.25000E+00	4.63509E-05
2.00000E+00	4.76834E-03	9.50000E+00	1.26017E-05
2.25000E+00	1.50027E-03	9.75000E+00	5.96812E-06
2.50000E+00	1.27006E-03	1.00000E+01	2.55140E-06
2.75000E+00	1.73171E-03	1.02500E+01	2.29040E-05
3.00000E+00	8.29311E-04	1.05000E+01	2.61052E-05
3.25000E+00	4.08413E-04	1.07500E+01	1.05605E-05
3.50000E+00	1.56385E-04	1.10000E+01	1.20267E-05
3.75000E+00	2.31282E-04	1.12500E+01	3.71844E-07
4.00000E+00	4.86137E-04	1.15000E+01	1.11907E-05
4.25000E+00	2.48955E-04	1.17500E+01	1.23187E-05
4.50000E+00	8.11339E-04	1.20000E+01	1.16290E-06
4.75000E+00	1.44337E-03	1.22500E+01	9.79553E-06
5.00000E+00	8.45374E-04	1.25000E+01	7.19564E-06
5.25000E+00	1.66191E-04	1.27500E+01	6.04181E-06
5.50000E+00	1.83173E-04	1.30000E+01	1.95717E-06
5.75000E+00	5.24042E-04	1.32500E+01	4.77129E-06
6.00000E+00	4.56897E-04	1.35000E+01	1.02387E-05
6.25000E+00	8.46994E-05	1.37500E+01	9.00195E-07
6.50000E+00	1.27405E-04	1.40000E+01	2.39094E-06
6.75000E+00	3.12072E-04	1.42500E+01	1.84977E-07
7.00000E+00	2.51538E-04	1.45000E+01	1.28007E-05
7.25000E+00	9.66544E-05	1.47500E+01	3.77961E-05
7.50000E+00	8.88143E-05	1.50000E+01	4.28828E-05

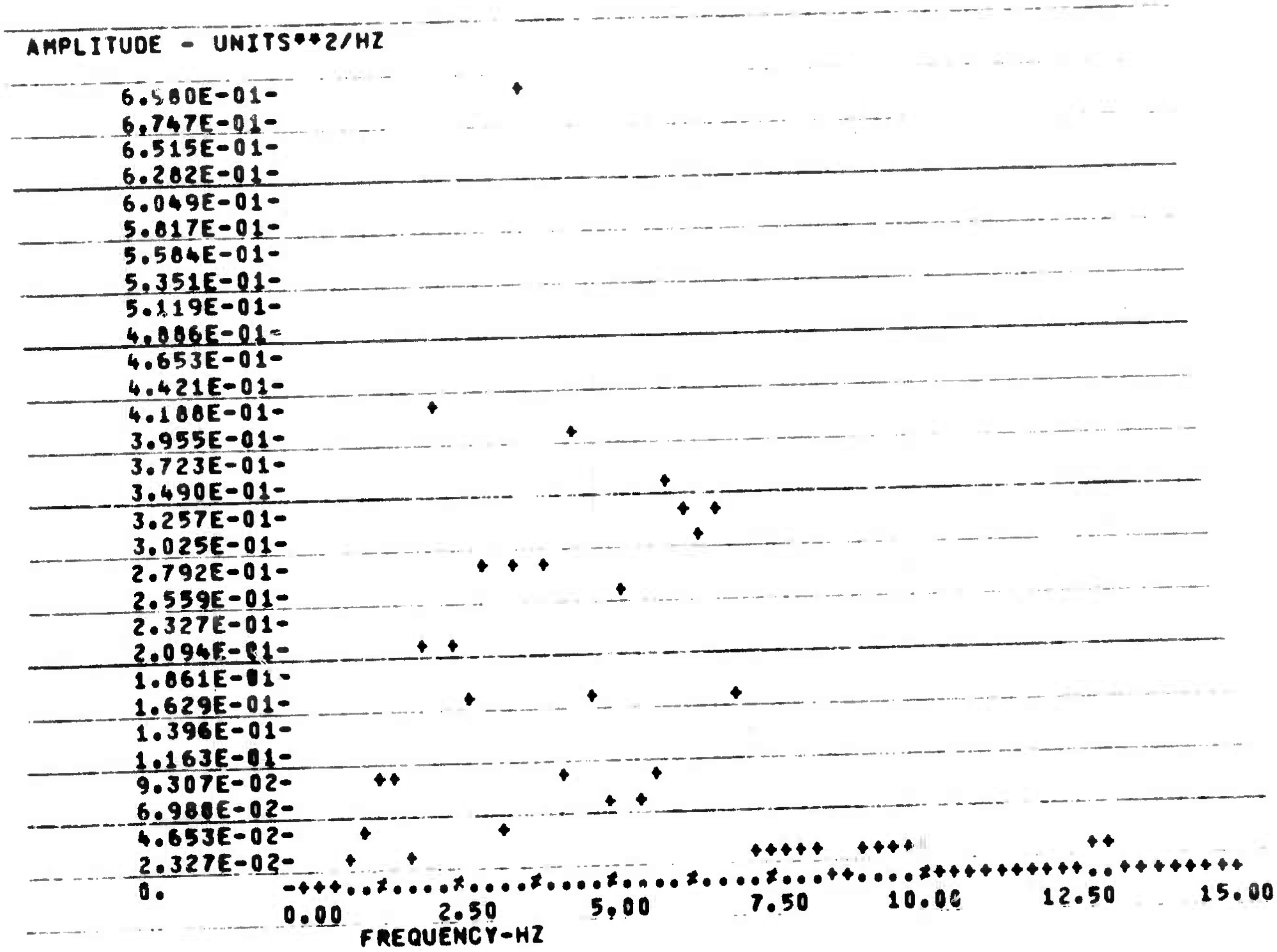


SPECTRAL DENSITY DIG CORR - Y AXIS
AMPLITUDE - UNITS**2/HZ
6.091E-03-
5.888E-03-
5.685E-03-
5.482E-03-
5.279E-03-
5.076E-03-
4.873E-03-
4.670E-03-
4.467E-03-
4.264E-03-
4.061E-03-
3.858E-03-
3.655E-03-
3.451E-03-
3.248E-03-
3.045E-03-
2.842E-03-
2.639E-03-
2.436E-03-
2.233E-03-
2.030E-03-
1.827E-03-
1.624E-03-
1.421E-03-
1.218E-03-
1.015E-03-
8.121E-04-
6.091E-04-
4.061E-04-
2.030E-04-
0.
0.00
2.50
5.00
7.50
10.00
12.50
15.00
FREQUENCY-HZ

SPECTRAL DENSITY EDGE - X AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	5.22392E-04	7.75000E+00	1.49173E-02
5.00000E-01	9.62093E-03	8.00000E+00	1.60504E-02
7.50000E-01	3.29392E-02	8.25000E+00	2.00008E-02
1.00000E+00	5.55437E-02	8.50000E+00	7.82808E-03
1.25000E+00	9.59366E-02	8.75000E+00	6.31732E-04
1.50000E+00	8.37296E-02	9.00000E+00	1.21796E-02
1.75000E+00	1.37576E-02	9.25000E+00	1.72670E-02
2.00000E+00	2.05713E-01	9.50000E+00	2.60883E-02
2.25000E+00	4.22969E-01	9.75000E+00	3.40770E-02
2.50000E+00	2.13671E-01	1.00000E+01	1.26750E-02
2.75000E+00	1.62969E-01	1.02500E+01	3.08861E-04
3.00000E+00	2.79209E-01	1.05000E+01	4.68160E-03
3.25000E+00	5.74321E-02	1.07500E+01	2.00221E-03
3.50000E+00	2.90117E-01	1.10000E+01	3.67423E-03
3.75000E+00	6.97994E-01	1.12500E+01	3.84031E-03
4.00000E+00	2.70490E-01	1.15000E+01	2.45711E-03
4.25000E+00	1.02819E-01	1.17500E+01	2.18421E-03
4.50000E+00	4.06045E-01	1.20000E+01	1.19714E-03
4.75000E+00	1.56363E-01	1.22500E+01	7.05543E-03
5.00000E+00	6.02069E-02	1.25000E+01	7.60909E-03
5.25000E+00	2.54842E-01	1.27500E+01	1.17655E-02
5.50000E+00	6.33277E-02	1.30000E+01	2.16876E-02
5.75000E+00	9.46634E-02	1.32500E+01	1.06083E-02
6.00000E+00	3.58619E-01	1.35000E+01	1.35475E-05
6.25000E+00	3.14706E-01	1.37500E+01	4.27600E-03
6.50000E+00	3.05595E-01	1.40000E+01	2.54876E-03
6.75000E+00	3.31761E-01	1.42500E+01	2.39066E-04
7.00000E+00	1.53000E-01	1.45000E+01	9.85898E-04
7.25000E+00	2.24262E-02	1.47500E+01	2.52407E-04
7.50000E+00	1.68352E-02	1.50000E+01	2.54612E-04

SPECTRAL DENSITY EDGE - X AXIS



SPECTRAL DENSITY EDGE - Y AXIS

FREQ - HZ	AMP - UNITS**2/HZ	FREQ - HZ	AMP - UNITS**2/HZ
2.50000E-01	4.10867E-03	7.75000E+00	3.99986E-03
5.00000E-01	3.74300E-02	8.00000E+00	5.84819E-03
7.50000E-01	6.78852E-02	8.25000E+00	2.28904E-03
1.00000E+00	4.12238E-02	8.50000E+00	1.89038E-04
1.25000E+00	1.70151E-02	8.75000E+00	1.26679E-03
1.50000E+00	3.13758E-02	9.00000E+00	3.71607E-03
1.75000E+00	4.83152E-02	9.25000E+00	3.81760E-03
2.00000E+00	8.60556E-02	9.50000E+00	1.48800E-03
2.25000E+00	1.23382E-01	9.75000E+00	1.54314E-04
2.50000E+00	8.32087E-02	1.00000E+01	1.36519E-04
2.75000E+00	2.94732E-02	1.02500E+01	5.66741E-04
3.00000E+00	1.34416E-02	1.05000E+01	6.08287E-04
3.25000E+00	4.69686E-03	1.07500E+01	1.58034E-04
3.50000E+00	4.44291E-02	1.10000E+01	1.10004E-04
3.75000E+00	1.12457E-01	1.12500E+01	2.49770E-04
4.00000E+00	1.07056E-01	1.15000E+01	4.41889E-04
4.25000E+00	7.36652E-02	1.17500E+01	3.40457E-04
4.50000E+00	7.52654E-02	1.20000E+01	1.35576E-04
4.75000E+00	5.77647E-02	1.22500E+01	8.71573E-04
5.00000E+00	2.13134E-02	1.25000E+01	1.02022E-03
5.25000E+00	9.27045E-03	1.27500E+01	2.75923E-04
5.50000E+00	6.97045E-03	1.30000E+01	9.98290E-04
5.75000E+00	3.04478E-03	1.32500E+01	1.67875E-03
6.00000E+00	4.04042E-03	1.35000E+01	5.81648E-04
6.25000E+00	4.56462E-03	1.37500E+01	4.37723E-04
6.50000E+00	6.37156E-03	1.40000E+01	1.73006E-03
6.75000E+00	1.39755E-02	1.42500E+01	1.90655E-03
7.00000E+00	1.63056E-02	1.45000E+01	1.01826E-03
7.25000E+00	6.60359E-03	1.47500E+01	3.61430E-04
7.50000E+00	1.05704E-05	1.50000E+01	1.52664E-04

SPECTRAL DENSITY EDGE - Y AXIS